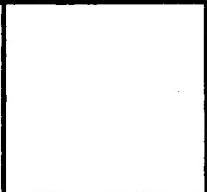


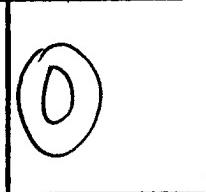
LOAN DOCUMENT

PHOTOGRAPH THIS SHEET

DTIC ACCESSION NUMBER



LEVEL



INVENTORY

Work Plan for a Treatability Study..

DOCUMENT IDENTIFICATION

Jan 95

DISTRIBUTION STATEMENT A

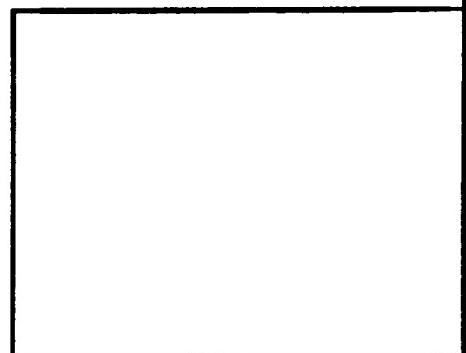
Approved for Public Release
Distribution Unlimited

DISTRIBUTION STATEMENT

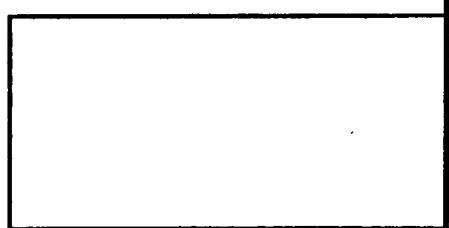
ACCESSIONED	
NTIS	GRAM
DTIC	TRAC
UNANNOUNCED	<input checked="" type="checkbox"/>
JUSTIFICATION	
BY	
DISTRIBUTION/	
AVAILABILITY CODES	
DISTRIBUTION	AVAILABILITY AND/OR SPECIAL
A-1	

DISTRIBUTION STAMP

H
A
N
D
L
E
W
I
T
H
C
A
R
E



DATE ACCESSIONED



DATE RETURNED



REGISTERED OR CERTIFIED NUMBER

20001122 056

DATE RECEIVED IN DTIC

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-FDAC

DRAFT

Work Plan for a Treatability Study in Support of the Intrinsic Remediation (Natural Attenuation) Option At Site OT-24, Pumphouse 75 (Site 57), and Site 56



**MacDill Air Force Base
Tampa, Florida**

Prepared For

**Air Force Center for Environmental Excellence
Brooks Air Force Base
San Antonio, Texas**

and

**56th Tactical Training Wing
MacDill Air Force Base
Tampa, Florida**

January 1995

AQM01-01- 0294

DEFENSE TECHNICAL INFORMATION CENTER
REQUEST FOR SCIENTIFIC AND TECHNICAL REPORTS

Title

AFCEE Collection

1. Report Availability (Please check one box)

- This report is available. Complete sections 2a - 2f.
 This report is not available. Complete section 3.

2a. Number of Copies Forwarded

1 each

2b. Forwarding Date

July/2000

2c. Distribution Statement (Please check ONE box)

- DaD Directive 5230.24, "Distribution Statements on Technical Documents," 18 Mar 87, contains seven distribution statements, as described briefly below. Technical documents MUST be assigned a distribution statement.*
- DISTRIBUTION STATEMENT A: Approved for public release. Distribution is unlimited.
 DISTRIBUTION STATEMENT B: Distribution authorized to U.S. Government Agencies only.
 DISTRIBUTION STATEMENT C: Distribution authorized to U.S. Government Agencies and their contractors.
 DISTRIBUTION STATEMENT D: Distribution authorized to U.S. Department of Defense (DoD) and U.S. DoD contractors only.
 DISTRIBUTION STATEMENT E: Distribution authorized to U.S. Department of Defense (DoD) components only.
 DISTRIBUTION STATEMENT F: Further dissemination only as directed by the controlling DoD office indicated below or by higher authority.
 DISTRIBUTION STATEMENT X: Distribution authorized to U.S. Government agencies and private individuals or enterprises eligible to obtain export-controlled technical data in accordance with DoD Directive 5230.25, Withholding of Unclassified Technical Data from Public Disclosure, 6 Nov 84.

2d. Reason For the Above Distribution Statement (in accordance with DaD Directive 5230.24)

2e. Controlling Office

HQ AFCEE

2f. Date of Distribution Statement Determination

15 Nov 2000

3. This report is NOT forwarded for the following reasons. (Please check appropriate box)

- It was previously forwarded to DTIC on _____ (date) and the AD number is _____
 It will be published at a later date. Enter approximate date if known.
 In accordance with the provisions of DoD Directive 3200.12, the requested document is not supplied because:

Print or Type Name

Laura Peña
Telephone
210-536-1431

Signature

Laura Peña

(For DTIC Use Only)
AQ Number

M01-01-0294

DRAFT

WORK PLAN FOR A
TREATABILITY STUDY
IN SUPPORT OF THE INTRINSIC REMEDIATION
(NATURAL ATTENUATION) OPTION
AT SITE OT-24, PUMPHOUSE 75 (SITE 57), AND SITE 56
MACDILL AIR FORCE BASE
TAMPA, FLORIDA

January 1995

Prepared for:

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
BROOKS AIR FORCE BASE
SAN ANTONIO, TEXAS

AND

56TH TACTICAL TRAINING WING
MACDILL AIR FORCE BASE
TAMPA, FLORIDA

Prepared by:

Parsons Engineering Science, Inc.
1700 Broadway, Suite 900
Denver, Colorado 80290

CONTENTS

1	INTRODUCTION.....	1-1
1.1	SCOPE OF CURRENT WORK PLAN.....	1-2
1.2	SITE BACKGROUND	1-3
1.2.1	Site OT-24.....	1-3
1.2.2	Pumphouse 75 (Site 57)	1-9
1.2.3	Site 56.....	1-10
2	DATA REVIEW AND CONCEPTUAL MODEL DEVELOPMENT	2-1
2.1	DATA REVIEW	2-1
2.1.1	Topography and Surface Hydrology	2-1
2.1.2	Overview of Geology and Hydrogeology	2-3
2.1.3	Soil Quality	2-14
2.1.4	Ground Water Quality and Chemistry	2-28
2.2	DEVELOPMENT OF CONCEPTUAL MODEL	2-41
2.2.1	INTRINSIC REMEDIATION AND THE BIOPLUME II MODEL	2-42
2.2.2	BIODEGRADATION OF DISSOLVED BTEX CONTAMINATION	2-42
2.2.3	Initial Conceptual Models	2-43
2.2.4	Potential Pathways and Receptors.....	2-45
3	COLLECTION OF ADDITIONAL DATA.....	3-1
3.1	SOIL SAMPLING	3-2
3.1.1	Sample Collection Using the Geoprobe® System	3-2
3.1.2	Soil Sample Locations and Required Analyses.....	3-5
3.1.3	Datum Survey.....	3-11
3.1.4	Site Restoration	3-11
3.1.5	Equipment Decontamination Procedures	3-11
3.2	SURFACE WATER AND SEDIMENT SAMPLING	3-12
3.2.1	Surface Water and Sediment Sampling Strategy and Required Analysis	3-13
3.2.2	Preparation for Sampling	3-14
3.2.3	Sampling Procedures.....	3-15
3.3	MONITORING POINT INSTALLATION	3-16
3.3.1	Monitoring Point Installation Locations and Completion Intervals.....	3-16
3.3.2	Monitoring Point Installation Procedures	3-18
3.3.3	Monitoring Point Development and Records.....	3-21
3.3.4	Monitoring Point Location and Datum Survey.....	3-22
3.3.5	Water Level Measurements.....	3-22
3.4	GROUND WATER SAMPLING PROCEDURES.....	3-22
3.4.1	Ground Water Sampling Strategy	3-25
3.4.2	Preparation for Sampling	3-25
3.4.3	Sampling Procedures.....	3-26
3.4.4	Onsite Ground Water Parameter Measurement.....	3-31

3.5 HANDLING OF SAMPLES FOR LABORATORY ANALYSIS.....	3-34
3.3.6 Laboratory Analyses	3-37
3.6 AQUIFER TESTING.....	3-37
3.6.1 Definitions.....	3-37
3.6.2 Equipment	3-38
3.6.3 General Test Methods	3-38
3.6.4 Falling Head Test	3-39
3.6.5 Rising Head Test.....	3-41
3.6.6 Slug Test Data Analysis	3-41
4 REMEDIAL OPTION EVALUATION AND TS REPORT	4-1
5 QUALITY ASSURANCE/QUALITY CONTROL	5-1
6 REFERENCES.....	6-1

**APPENDIX A CONTAINERS, PRESERVATIVES, PACKAGING, AND
 SHIPPING REQUIREMENTS FOR GROUND WATER SAMPLES**

APPENDIX B ADDITIONAL SITE DATA

TABLES

	Page
2.1 Summary of Monitoring Well Construction Details Site OT-24	2-8
2.2 Summary of Ground Water Level and Free Product Measurements Site OT-24	2-10
2.3 Summary of Monitoring Well Construction and Hydrocone Punch Details and Ground Water Level Measurements Pumphouse (Site 57)	2-12
2.4 Summary of Monitoring Well Construction Details and Ground Water Level Measurements Site 56	2-14
2.5 Summary of Soil Analytical Data Site OT-24	2-17
2.6 Summary of Organic Vapor Analyzer Data Site OT-24	2-20
2.7 Summary of Headspace Screening Results Pumphouse (Site 57)	2-21
2.8 Summary of Soil Analytical Data Pumphouse (Site 57).....	2-23
2.9 Summary of Headspace Screening Results Site 56.....	2-26
2.10 Summary of Soil Analytical Data Site 56	2-28
2.11 Summary of Hydrocone Ground Water Analytical Data Site OT-24	2-31
2.12 Summary of Monitoring Well Ground Water Analytical Data Site OT-24	2-32
2.13 Summary of Ground Water Analytical Data Pumphouse 75 (Site 57)	2-36
2.14 Summary of Ground Water Analytical Data Site 56.....	2-39
3.1 Analytical Protocol for Ground Water and Soil.....	3-3
4.1 Example TS Report Outline	4-2
5.1 QA/QC Sampling Program	5-2

FIGURES

	Page
1.1 Regional Location Map.....	1-4
1.2 Site Location Map Site OT-24	1-5
1.3 Site Layout Site OT-24	1-6
1.4 Site Layout Pumphouse (Site 57).....	1-7
1.5 Site Layout Site 56.....	1-8
2.1 Regional Topographic Map.....	2-2
2.2 Location of Hydrogeologic Cross-Sections Site OT-24	2-5
2.3 Hydrogeologic Cross-Section A-A' Site OT-24	2-6
2.4 Hydrogeologic Cross-Section B-B' Site OT-24	2-7
2.5 Water Table Elevation Map Site OT-24	2-11
2.6 Water Table Elevation Map Pumphouse 75 (Site 57).....	2-13
2.7 Water Table Elevation Map Site 56.....	2-16
2.8 Estimated Areal Extent of Soil BTEX Contamination Site OT-24.....	2-18
2.9 Soil VOC Headspace Screening Locations and Isopleth Map Pumphouse 75 (Site 57).....	2-22
2.10 Estimated Areal Extent of Soil BTEX Contamination Pumphouse 75 (Site 57).....	2-24
2.11 Soil VOC Headspace Screening Locations and Isopleth Map Site 56.....	2-27
2.12 Estimated Areal Extent of Soil BTEX Contamination Site 56	2-29
2.13 Estimated Areal Extent of Ground Water BTEX Contamination 1989 Site OT-24	2-33
2.14 Estimated Areal Extent of Ground Water BTEX Contamination 1994 Site OT-24	2-34
2.15 Estimated Areal Extent of Ground Water BTEX Contamination Pumphouse 75 (Site 57).....	2-38
2.16 Estimated Areal Extent of Ground Water BTEX Contamination Site 56.....	2-40
3.1 Cross Section of Geoprobe®	3-4
3.2 Geologic Boring Log.....	3-6
3.3 Proposed Geoprobe® Sampling and Monitoring Point Installation Locations Site OT-24	3-7
3.4 Proposed Geoprobe® Sampling and Monitoring Point Installation Locations Pumphouse 75 (Site 57)	3-9
3.5 Proposed Geoprobe® Sampling and Monitoring Point Installation Locations Site 56	3-10
3.6 Monitoring Point Installation Record	3-20
3.7 Monitoring Point Development Record	3-23
3.8 Ground Water Sampling Record	3-27
3.9 Aquifer Slug Test Data Form.....	3-39

SECTION 1

INTRODUCTION

This work plan, prepared by Parsons Engineering Science, Inc. (Parsons ES), presents the scope of work for the collection of data necessary to conduct a treatability study (TS) for remediation of ground water contaminated with petroleum hydrocarbons at three sites located at MacDill Air Force Base (AFB) in Tampa, Florida, (the Base). The three sites are the Energy Management Test Laboratory (Site OT-24), Pumphouse 75 (Site 57), and the Army Air Force Exchange Service (AAFES) Gas Station (Site 56).

Several remedial options will be evaluated during the TS, including free product removal; bioventing for source removal; air sparging; and natural contaminant attenuation (intrinsic remediation) with long-term monitoring. All hydrogeologic and ground water chemical data necessary to evaluate the various remedial options will be collected under this program; however, this work plan is primarily oriented toward the collection of hydrogeologic data to be used as input into the Bioplume II ground water model in support of intrinsic remediation for restoration of fuel-hydrocarbon-contaminated ground water.

As part of the TS, the Bioplume II modeling effort has three primary objectives: 1) to predict the future extent and concentration of the dissolved-phase contaminant plume by modeling the effects of advection, dispersion, sorption, and biodegradation; 2) to assess the possible risk to potential downgradient receptors; and 3) to provide technical support for selection of the intrinsic remediation option as the best remedial alternative at regulatory negotiations, as appropriate. The Bioplume II modeling effort for the three sites will involve completion of several tasks, which are described in the following sections.

This work plan was developed based on discussions among representatives from the Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division, Florida Department of Environmental Protection (FDEP), and Parsons ES at a meeting at the Base on November 16, 1994; on the statement of work (SOW) for this project; and on a review of existing site characterization data. All field work will follow the health and safety procedures presented in the program *Health and Safety Plan for Bioplume II Modeling Initiative* (ES, 1993) and the site-specific addendum to the

program Health and Safety Plan. This work plan was prepared for AFCEE and MacDill AFB.

1.1 SCOPE OF CURRENT WORK PLAN

The ultimate objective of the work described herein is to provide a TS for remediation of ground water contamination at Site OT-24, Pumphouse 75 (Site 57), and Site 56. However, this project is part of a larger, broad-based initiative being conducted by AFCEE in conjunction with the US Environmental Protection Agency (EPA) and Parsons ES to document the biodegradation and resulting attenuation of fuel hydrocarbons dissolved in ground water, and to model this degradation using the Bioplume II numerical ground water model. For this reason, the work described in this work plan is directed toward the collection of data in support of this initiative. All data required to develop a 30-percent design of an alternate remediation system, should intrinsic remediation not prove to be a viable remedial option at this facility, also will be collected under this program. This work plan describes the site characterization activities to be performed in support of the TS and the Bioplume II modeling effort.

Proposed site characterization activities in support of the TS include: 1) determination of preferential contaminant migration pathways; 2) soil sampling using Geoprobe® direct push technology; 3) ground water monitoring point placement; 4) ground water sampling; and 5) aquifer testing. The materials and methodologies required for performance of these activities are described herein. Existing site-specific data and data collected during the supplemental site characterization activities described in this work plan will be used as input for the Bioplume II model. Where site-specific data are not available, conservative values for the types of aquifer materials present at the site obtained from widely accepted published literature will be used for model input. Sensitivity analyses will be conducted for the parameters which are known to have the greatest influence on the results of Bioplume II modeling, and where possible, the model will be calibrated using historical site data. Upon completion of the Bioplume II modeling, Parsons ES will provide technical assistance during regulatory negotiations to support the intrinsic remediation option if the results of the modeling indicate that this approach is warranted. If it is shown that intrinsic remediation is not the most appropriate remedial option, Parsons ES will recommend the most appropriate ground water remedial technology based on available data.

This work plan consists of six sections, including this introduction. Section 2 presents a review of existing site-specific data and a conceptual model for the site. Section 3 describes the proposed sampling strategy and procedures to be used for the collection of additional site characterization data. Section 4 describes the remedial option evaluation procedure and TS report format. Section 5 describes the quality assurance/quality control (QA/QC) measures to be used during this project. Section 6 contains the references used in preparing this document. There are two appendices to this work plan. Appendix A contains a listing of containers, preservatives, packaging, and

shipping requirements for ground water samples. Appendix B contains a summary of existing soil and ground water analytical data from previous field investigation work.

1.2 SITE BACKGROUND

The Base, located on the southermost tip of the Interbay Peninsula, covers nearly 7,000 acres in Hillsborough County, Florida, immediately south of the City of Tampa (Figure 1.1). The Base is bordered to the north by the City of Tampa, Florida, to the east by Hillsborough Bay, and to the south and west by Tampa Bay. The home of the 56th Tactical Training Wing, the Base was established in the early 1950's. The sites of interest for this study are the area adjacent to the Energy Management Test Laboratory (Site OT-24), the area surrounding Pumphouse 75 (Site 57), and the area adjacent to the AAFES Gas Station (Site 56). Site OT-24 is located in the northwestern portion of MacDill AFB, northwest of the runway (Figure 1.2). Pumphouse 75 (Site 57) is located in the northeast section of the Base, to the northeast of the runway. Site 56 is positioned at the intersection of Tampa Boulevard (Blvd.) and Hangar Loop Road (Rd.) in the northeastern portion of the Base. Soil and groundwater contamination at Site OT-24 have been attributed to waste disposal practices in the drain fields south of the Energy Management Test Laboratory, an active fuels testing laboratory (Figure 1.3). At Pumphouse 75 (Site 57), the soil and groundwater contamination originated as fuel released from underground storage tanks (USTs) and underground piping beneath and adjacent to the pumphouse (Building 75) (Figure 1.4). Contamination at Site 56 originated from USTs and pipelines associated with the AAFES gasoline station (Figure 1.5).

1.2.1 Site OT-24

The Energy Management Test Laboratory shown in Figure 1.3 is located east of the fuel tank farm and south of the fuel dispensing area. The sources of contamination are two drain fields located in a grassy area south of the laboratory, an oil/water separator, and a tank used for storing waste petroleum. The western drain field was used for sanitary waste disposal and the eastern drain field was utilized as an acid neutralizing drain.

Contamination was first reported by construction crews working on the roadway south of the Energy Management Test Laboratory. During periods of significant precipitation, a black, viscous material has been noticed seeping from the road cut (CH2M Hill, 1991a). The release of hydrocarbons from the oil/water separator and/or plugging of the drain fields are the suspected source(s). The waste petroleum tank was also found to contain fuel components and acetone.

Installation Restoration Program (IRP) action was initiated at the Base in 1988 when the Hazardous Waste Remedial Actions Program (HAZWWRAP) retained CH2M Hill to

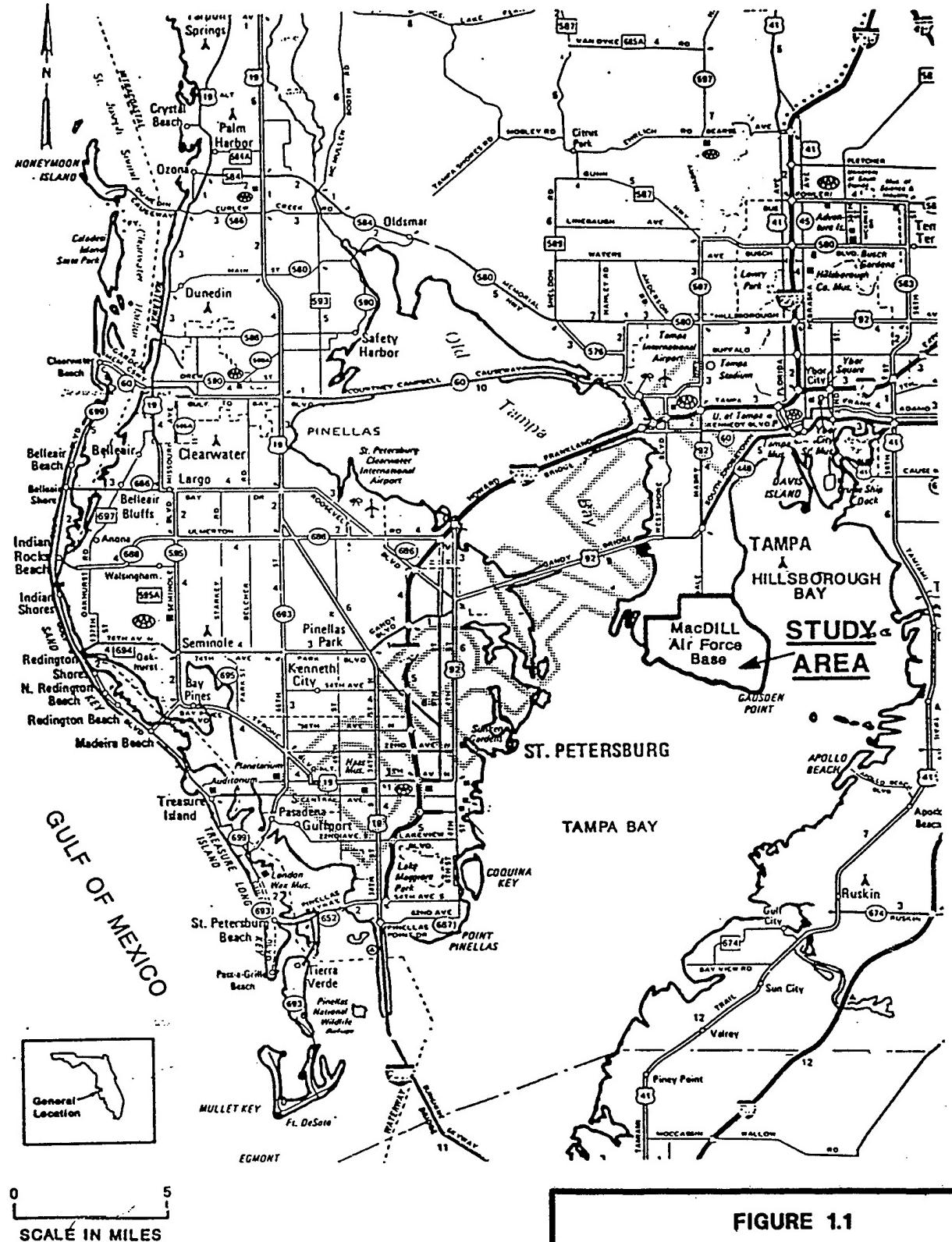


FIGURE 1.1
REGIONAL LOCATION MAP

Intrinsic Remediation TS
MacDill Air Force Base, Florida



**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

Source: CH₂M Hill, 1991b

M:\45021\DRAWINGS\95DN0021 at 9:30

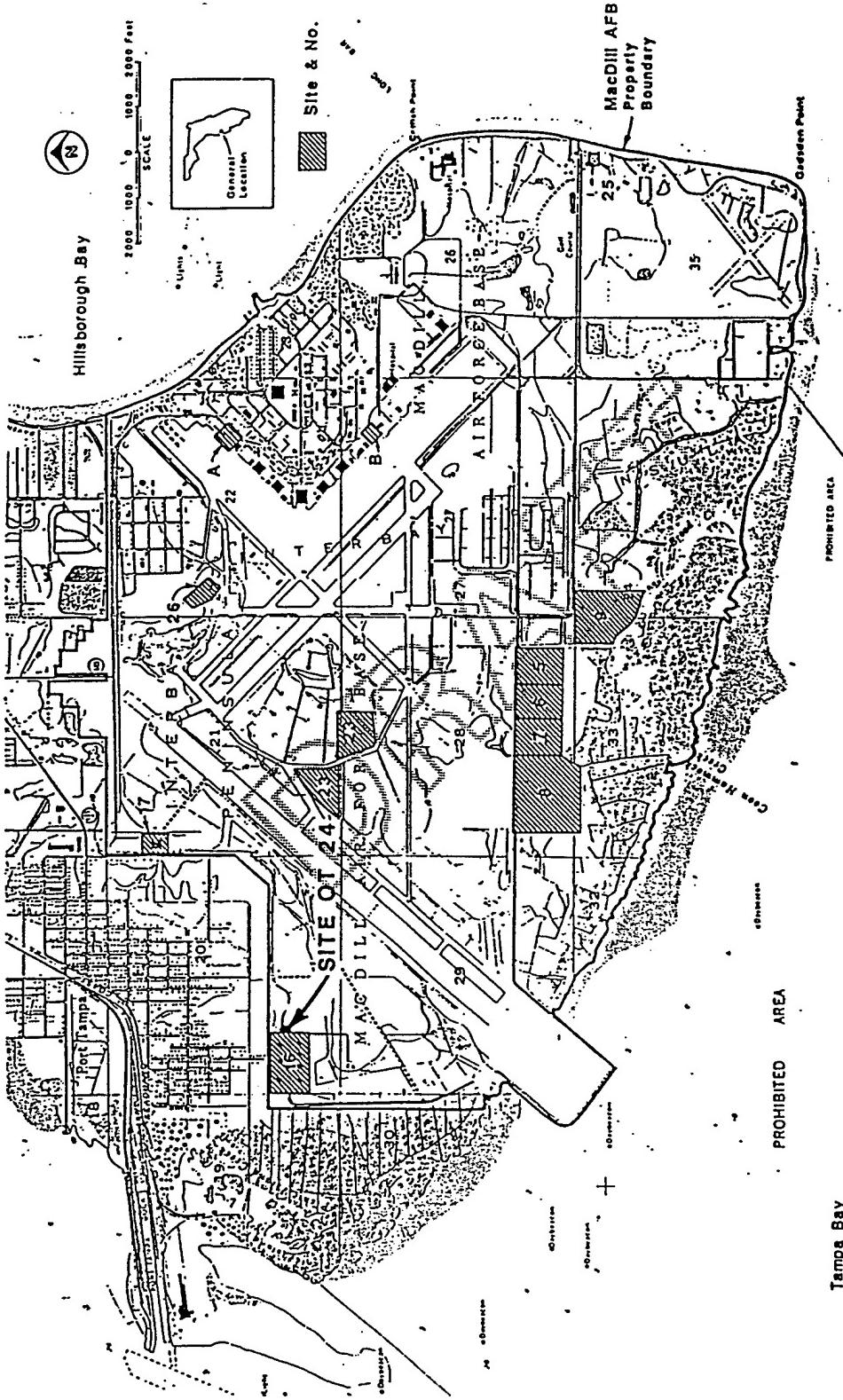


FIGURE 1.2
SITE LOCATION MAP
SITE OT-24

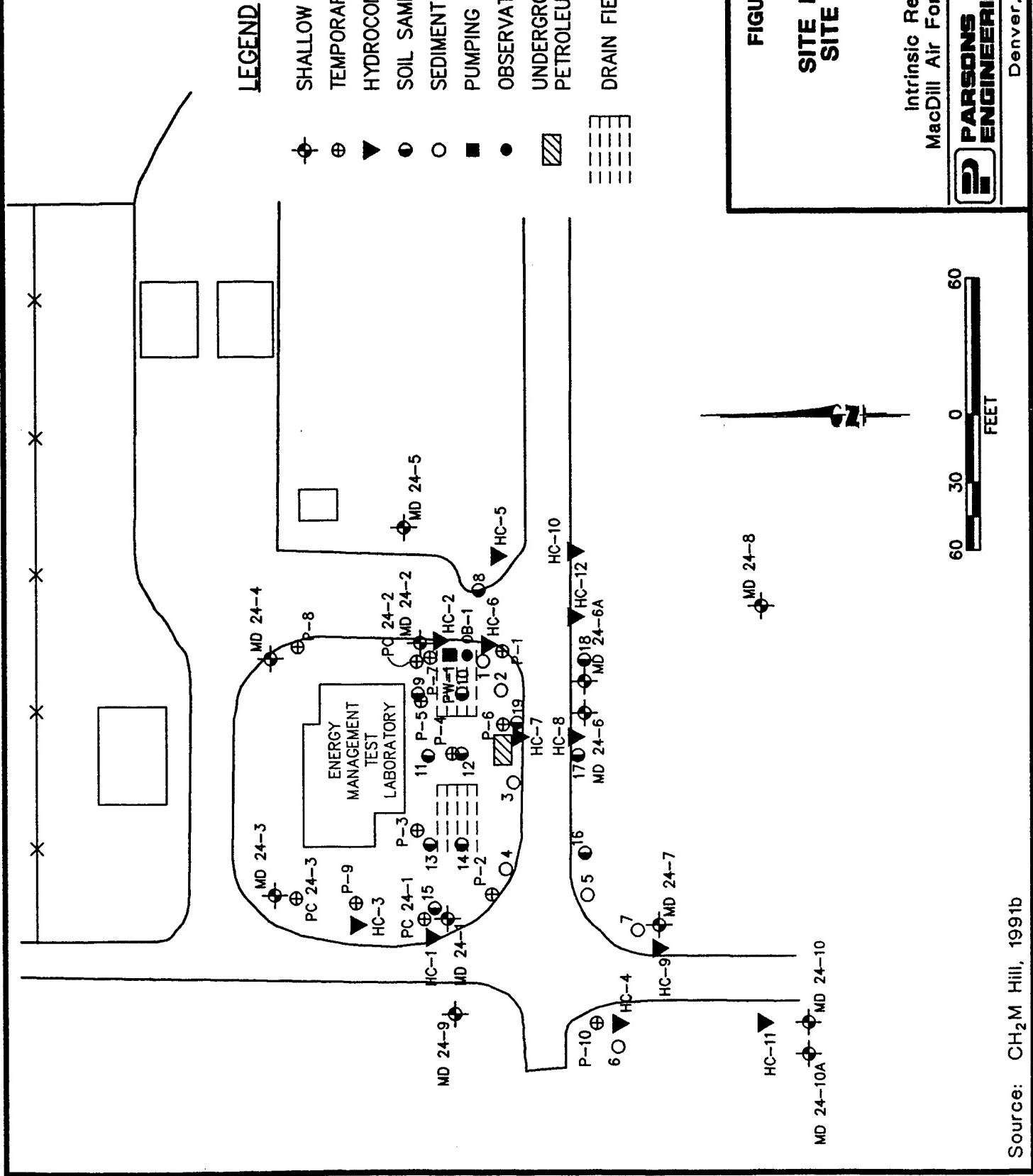
Site OT-24
Intrinsic Remediation TS
MacDill Air Force Base, Florida

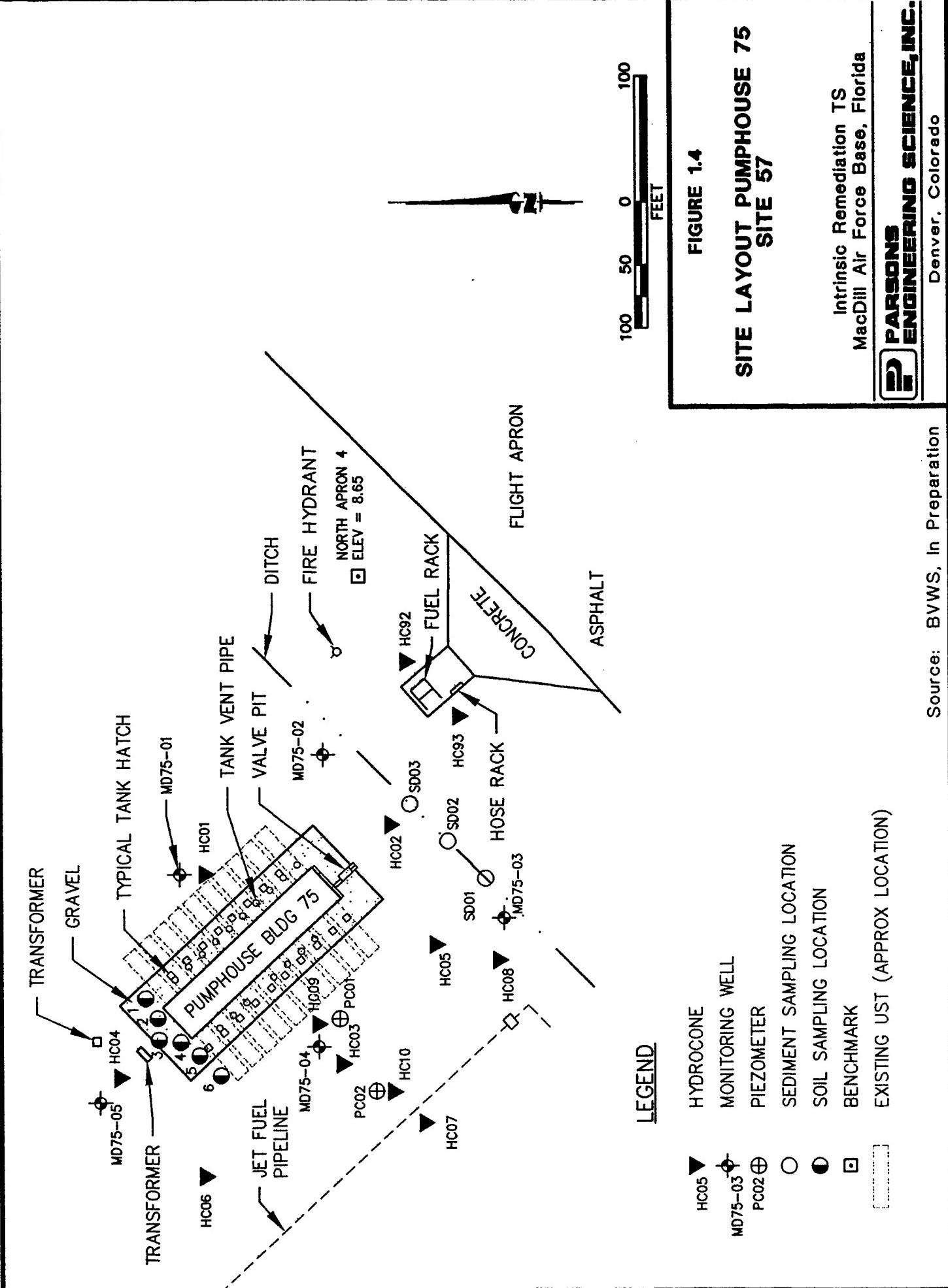
PATSONS
ENGINEERING SCIENCE, INC.

Denver, Colorado

Source: CH2M Hill, 1991b

M:\45021\DRAWINGS\95DN0015, 1/25/95 at 7:30





LEGEND

- MONITORING WELL
- ▼ HYDROCONE
- ⊕ PIEZOCONE
- ▽ BENCHMARK

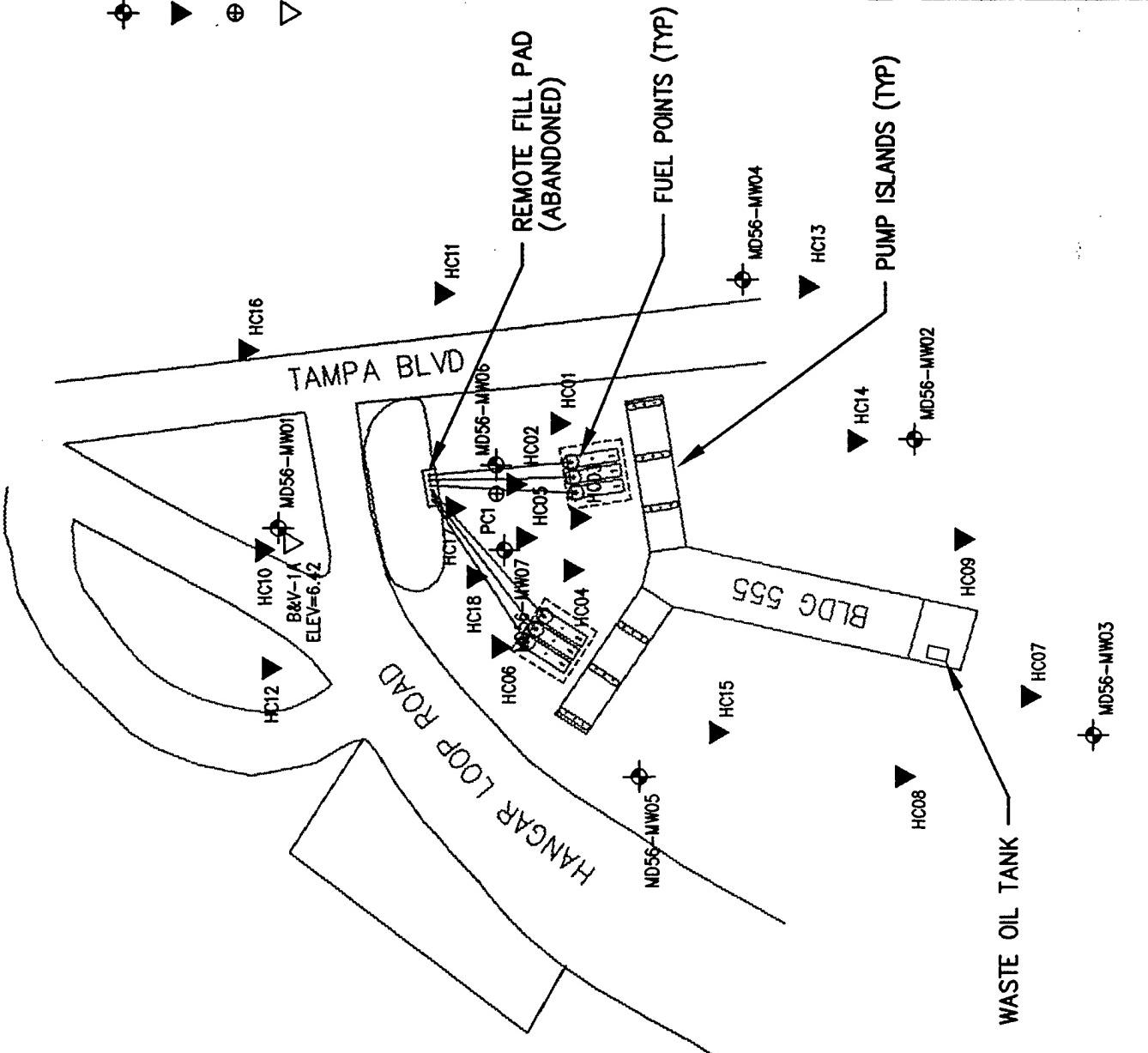


FIGURE 1.5

SITE LAYOUT SITE 56

Intrinsic Remediation TS
MacDill Air Force Base, Florida

PARSONS
ENGINEERING SCIENCE, INC.

Denver, Colorado

Source: BVWS, In Preparation

M:\45021\DRAWINGS\94DN1527, 1/25/95 at 9:00

conduct a contaminant assessment of Site OT-24. The Site OT-24 preliminary contaminant assessment, conducted in November 1988, involved the installation of 4 monitoring wells (MD 24-1 through MD 24-4). In April 1989, 3 piezocones soundings and 13 hydrocone tests were performed to further evaluate the horizontal and vertical extent of contamination as well as the hydraulic properties of the aquifer. Ten temporary well points were installed and sampled to define the extent of the dissolved contaminant plume and results from these well point samples were the basis for installing 6 additional monitoring wells in July 1989 (MD 24-6 through MD 24-10). A test pumping well and observation well were also installed in July 1989, to conduct an aquifer pumping test at the site. In August 1989, a 48-hour aquifer test was performed to determine the hydraulic characteristics of the surficial aquifer. Ten monitoring points were installed in September 1989 to determine the extent of the free product plume. The Contaminant Assessment Report (CAR) prepared by CH2M Hill identified the presence of dissolved and undissolved hydrocarbon contamination originating near the fuels test laboratory and migrating to the southwest. Twelve soil samples and 7 sediment samples also were collected during field efforts associated with preparation of the CAR. The CAR was submitted to the Florida Department of Environmental Regulation (FDER) in April 1990 and comments by the FDER were received by CH2M Hill in June 1990. Responses to the FDER comments were submitted to the FDER by CH2M Hill in September 1990. A Contamination Assessment Report Addendum (CARA) was submitted by CH2M Hill (1991a) in April 1991. During supplemental site investigations implemented for the CARA, two additional deep monitoring wells, MD 24-6A and MD 24-10A, were installed in September 1990 to further determine the vertical extent of contamination (CH2M Hill, 1991a). After 1991, a product recovery system was installed at the site. Three ground water pumping wells and two product recovery wells were installed along with a pneumatic pump. The recovery system is not in use at the site at this time (CH2M Hill, 1991b).

1.2.2 Pumphouse 75 (Site 57)

At Pumphouse 75 (Site 57), 20 50,000-gallon USTs are used to store JP-4 jet fuel for refueling aircraft along the north apron of the flightline (Figure 1.4). The 20 USTs are presumed to lie perpendicular to the pumphouse (Building 75) as shown in Figure 1.4 and are considered a source of petroleum contamination. A jet fuel pipeline located west of the pumphouse building is connected to a valve and pump-off pit near the flight apron. Contaminant assessments have identified the pipeline and the pit as a sources of contamination also. Pumphouse 75 is the only active fuel pumphouse on the Base [Black and Veatch Waste Science, Inc. (BVWS), In Preparation].

In addition to petroleum contamination, transformers located in a control room within Pumphouse 75 leaked transformer fluid, causing polychlorinated biphenyl (PCB) contamination of soils. Prior to 1980, small leaks of transformer fluid were reported, and

the spills were reportedly removed using absorbent material, which was drummed, and removed from the site. The transformer has been removed from the control room.

BVWS is preparing a CAR for Pumphouse 75 (Site 57) for the initial field work performed at the Base from September 1993 through February 1994. At Pumphouse 75, five monitoring wells were installed to characterize the ground water beneath the site. In addition, 10 hydrocone, 2 piezocene, and 207 headspace samples were obtained. The analysis of these samples indicated the presence of hydrocarbons, PCBs, and chlorinated compounds. Subsurface and surface soil samples were obtained during the installation of the monitoring wells. An additional six surface soil samples and three sediment samples also were collected at other locations. Analysis of the soil samples indicated elevated hydrocarbon concentrations in the vadose zone near the suspected source area and extending southeastward in the direction of ground water flow. Initial analytical results indicated data gaps, which were addressed during a second field investigation effort occurring from June through November, 1994. Only rough data summaries for both soil and ground water contaminants are available from BVWS (In Preparation) at this time.

1.2.3 Site 56

Beneath Site 56, an active gasoline station, lie six 5,100-gallon USTs containing various grades of gasoline and one 500-gallon UST containing waste motor oil. The 5,100-gallon tanks lie to the north of the pump islands, and the 500-gallon tank is positioned beneath the gas station building (Building 555). Figure 1.5 presents the site layout for Site 56. Pipelines run from the tanks to the pump islands and from the tanks to an abandoned remote fill pad located north of the tanks. Prior to being equipped with overfill shut-off valves to prevent spillage, spills involving the six gasoline USTs occurred. Sources of contamination at Site 56 include areas of past spills around the tanks six larger USTs, leakage from these tanks, and/or leakage from pipelines leading from the tanks to the abandoned remote filling pad.

As part of the CAR being developed by BVWS (In Preparation), 18 hydrocone ground water screening samples were collected in September 1993. One piezocene sounding was performed, seven monitoring wells were installed, and seven ground water samples were collected in November 1993. In February 1994, soil gas headspace screening was performed at 55 locations to delineate soil contamination at Site 56. Soil samples were also collected during the installation of the 7 monitoring wells. In February 1994, ground water measurements activities were performed during one tidal cycle (BVWS, In Preparation).

SECTION 2

DATA REVIEW AND CONCEPTUAL MODEL DEVELOPMENT

Existing site-specific data were reviewed and used to develop conceptual models of the ground water flow and contaminant transport regimes for Site OT-24, Pumphouse 75 (Site 57), and Site 56. These conceptual models will allow efficient collection of additional data which will be used to support the Bioplume II modeling effort and to evaluate potential remediation technologies, including intrinsic remediation. Sections 2.1 and 2.2 present a synopsis of available site data. Section 2.3 presents the preliminary conceptual ground water flow and solute transport models which were developed based on these data.

2.1 DATA REVIEW

The following sections were based upon review of the following site investigation reports:

- Contaminant Assessment Report- CH2M Hill (1990)
- Contaminant Assessment Report Addendum- CH2M Hill (1991a)
- Remedial Action Plan- CH2M Hill (1991b)
- Contaminant Assessment Report- Black and Veatch Waste Science, Inc (In Preparation)

2.1.1 Topography and Surface Hydrology

The Base is located on the western edge of Central Florida in the Southeast Coastal Plain Physiographic Region, a region characterized by slight local relief and low elevations. Elevations at the Base range from 0 to 12 feet above mean sea level (msl). The average elevation at Site OT-24 is approximately 4 feet above msl. Land surface elevations vary approximately 0.5 foot across Site OT-24, resulting in slow drainage and standing water in low areas. Vegetation consist of pine forests, cypress groves, and mangrove swamps. A topographic map of the Base area is presented in Figure 2.1 (CH2M Hill, 1991a; Driscoll, 1986; Espenshade, 1986; USGS, 1986 and 1987).

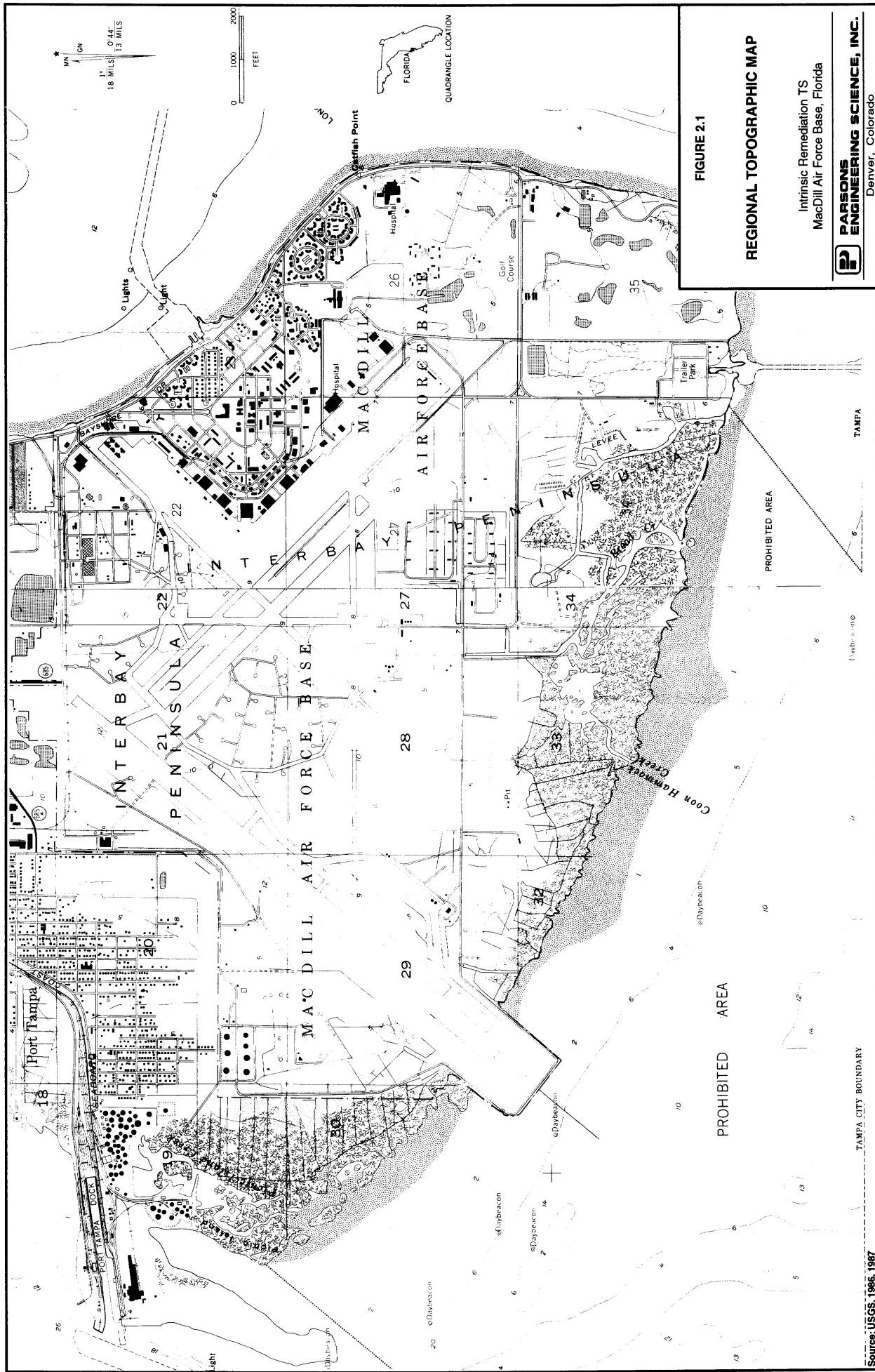


FIGURE 2.1
REGIONAL TOPOGRAPHIC MAP

Intrinsic Remediation TS
MacDill Air Force Base, Florida

**PARSONS
ENGINEERING SCIENCE, INC.**
Denver, Colorado

Source: USGS 1986, 1987

Major surface water bodies near the Base include Tampa Bay, which borders the Base to the west and south; Hillsborough Bay, which forms the eastern border of the Base; and the Gulf of Mexico, which lies approximately 19 miles to the west (Figure 1.1). Three major tidal streams flow across the Base and empty into Tampa Bay: Coon Hammock Creek, Picnic Island Creek, and Broad Creek (Figure 2.1). Each creek terminates in the mangrove swamp which fringes the southern perimeter of the Interbay Peninsula. A number of smaller intermittent and perennial tidal streams, storm drains, and drainage canals traverse through the Base. Runoff of surface water is carried by stormwater canals into tidal streams or drainage canals which empty into Tampa Bay. At Site OT-24, direct surface runoff from the site enters ditches and swales directly south of the drain field (Figure 1.3). Standing water collects in these areas during periods of high precipitation (CH2M Hill, 1991a; and USGS, 1986 and 1987).

2.1.2 Overview of Geology and Hydrogeology

2.1.2.1 Local Geology and Hydrogeology

MacDill AFB and central Florida lie within the Atlantic Coastal Plain Geologic Province, an region defined by thick, unconsolidated to consolidated marine sediments that form a wedge which thins inland. These marine sediments generally overlie crystalline bedrock. The Atlantic Coastal Plain bedrock in the Central Florida area are Miocene age rocks comprised of clastic sediments, sandy limestones, and dolomites (CH2M Hill, 1991a).

On the Base, surficial deposits consist of 20- to 60-foot-thick layers of fine quartz sand, fine silty sand, and clayey sand which form the surficial aquifer and overlie a clay unit. Previous studies have found the contact between the clayey sand and the clay, which defines the base of the surficial aquifer, to be indistinct. The Tampa Limestone Formation is found beneath the clay. In the Central Florida Region, the Tampa Limestone has an irregular surface of solution cavities and voids. At the Base, subsidence has occurred as a result of changing surface loading conditions associated with compaction and excavation. In 1981, a drilling operation caused a sinkhole near the Energy Management Test Laboratory and minor subsidence events have also occurred in unpaved areas of the Base (CH2M Hill, 1990 and 1991a).

Regionally, the hydrogeology of Central Florida is a multilayered aquifer system consisting of unconfined surficial aquifers and multiple confined limestone aquifers. The karsts of the Tampa Limestone form the uppermost confined limestone aquifer. The limestones of the confined Floridan Aquifer, which provides water for most of Florida and the southern third of Georgia, lie beneath the Tampa Limestone aquifer (CH2M Hill, 1990 and 1991a and Driscoll, 1986).

At the Base, the surficial aquifer is defined by the base of the clayey sand and ranges in thickness from 20 to 60 feet. The surficial aquifer is unconfined and is

influenced by tidal variances in some areas of the Base. Ground water lies within 1 to 5 feet of the ground surface. The Tampa Limestone aquifer, which lies beneath the surficial aquifer, is confined and is estimated to be approximately 100 feet thick in the Tampa area. The Tampa Limestone aquifer has been shown to be influenced by tidal fluctuations at some sites on the Base. In some areas beneath the Base, the surficial and Tampa Limestone aquifers may be hydraulically connected. No significant upward or downward vertical hydraulic gradients have been identified in either the surficial or Tampa Limestone aquifer systems. Ground water flow in the surficial aquifer generally follows local topography toward the nearest bay or drainage canal (CH2M Hill, 1990 and 1991a).

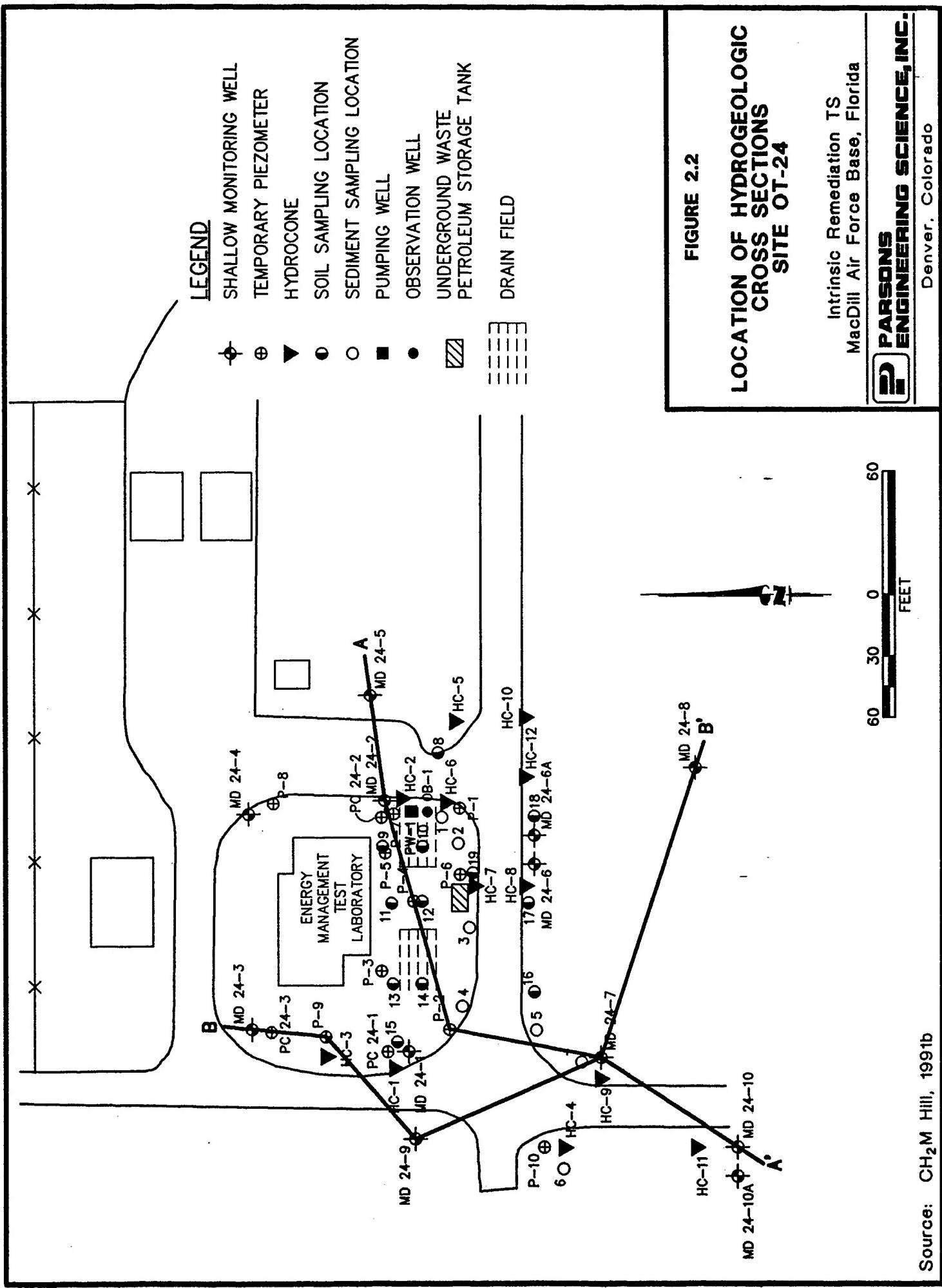
The surficial aquifer and the Tampa Limestone aquifer are not used as sources of potable water for the Base. However, the Tampa Limestone aquifer is a major source of drinking water in western and central Florida. Municipalities and industries are supplied with water from the Tampa Limestone by well fields located north of Tampa. The City of Tampa provides the water supply for the Base (CH2M Hill, 1990 and CH2M Hill, 1991a).

2.1.2.2 Site Geology and Hydrogeology

2.1.2.2.1 Site OT-24

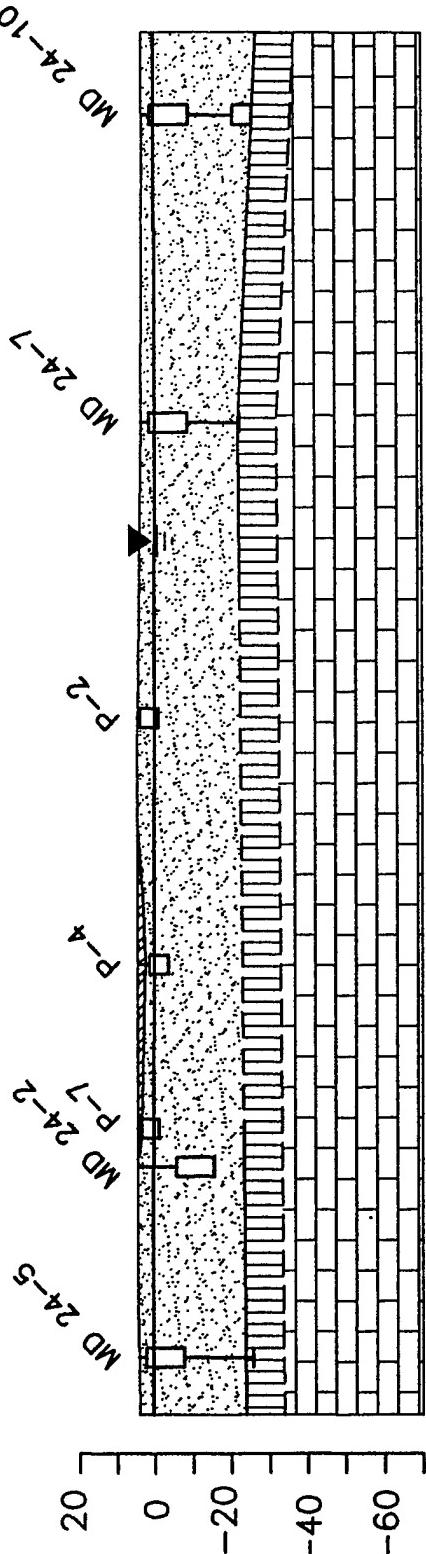
During contaminant assessment activities performed by CH2M Hill (1990, and 1991a), 10 borings were performed with a hollow-stem auger and completed as monitoring wells. Borehole depths range from 12 to 57 feet below ground surface (bgs), with the majority of holes drilled to approximately 20 feet bgs. Three piezocene soundings were conducted to depths ranging from 28 to 50 feet bgs to determine aquifer characteristics. Ten additional borings were performed with a hand auger and were finished as temporary monitoring points. Depths of the temporary points ranged from 6 to 9 feet bgs. Twelve soil samples and seven sediment samples also were obtained during site assessment efforts. Two supplementary borings were drilled to approximately 30 feet bgs and completed as wells during site investigation activities associated with the CARA (Figure 1.3). The locations of hydrogeologic cross section lines are shown in Figure 2.2. Figures 2.3 and 2.4 present the hydrogeologic cross sections developed from boring logs produced during the contaminant assessment effort. Table 2.1 presents well completion data for Site OT-24.

Subsurface soil observed at the site consisted of a sand and silty sand to a depth ranging from 25 to 56 feet bgs. Areas of limestone fill are present at the ground surface near the Energy Management Test Laboratory. An intermittent layer of clayey sand underlies the sands. The clayey sand is underlain by a highly plastic clay. In borehole MD 24-9, the clay unit was found at 56 feet bgs. Approximately 100 feet to the southeast



SW

A



Elevation (Feet Above Mean Sea Level)

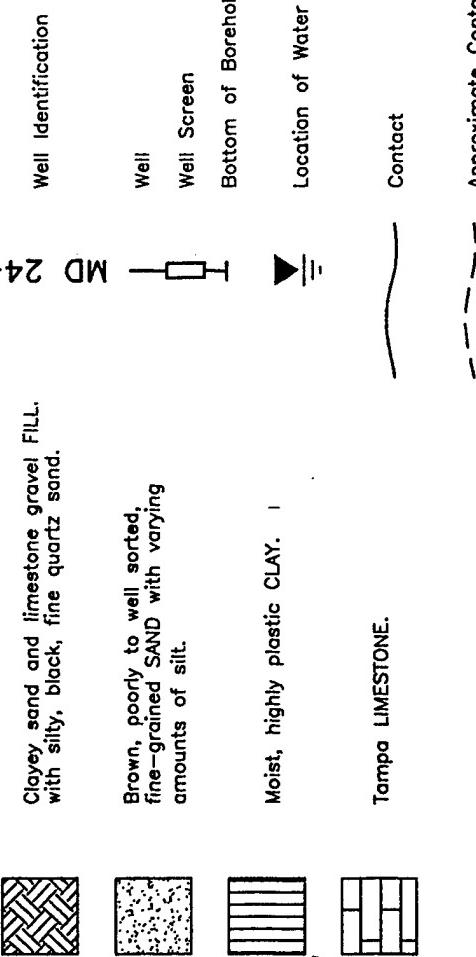


FIGURE 2.3

**HYDROGEOLOGIC
CROSS-SECTION A-A'
SITE OT-24**

Intrinsic Remediation TS
MacDill Air Force Base, Florida

**PARSONS
ENGINEERING SCIENCE, INC.**

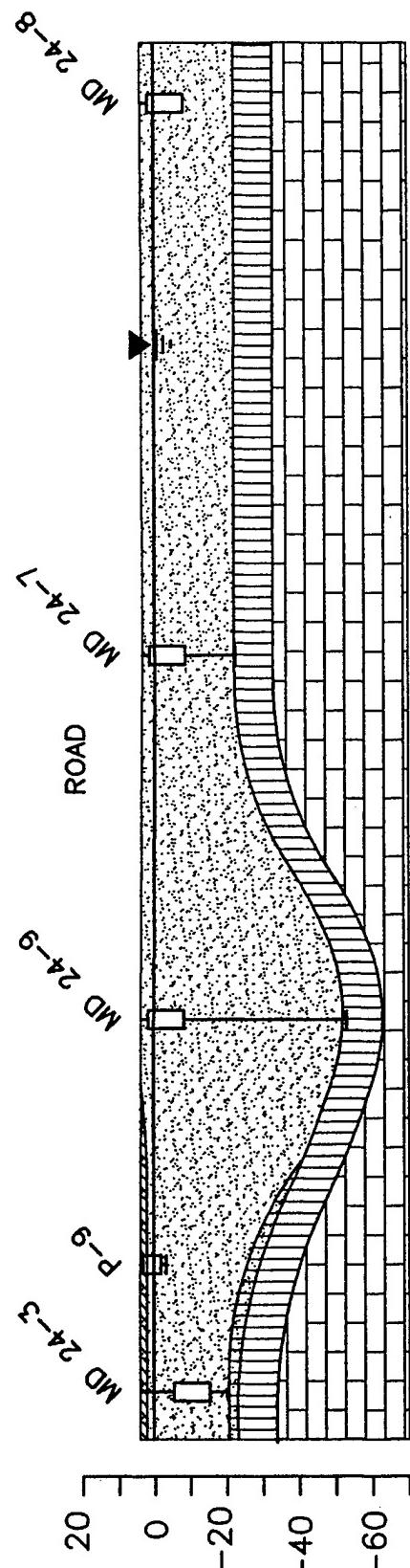
Denver, Colorado

Source: CH₂M Hill, 1991

M:\45021\DRAWINGS\XSECTION\95DN0019, 1/25/95 at 10:55

NW
B

SE
B'



Elevation (Feet Above Mean Sea Level)

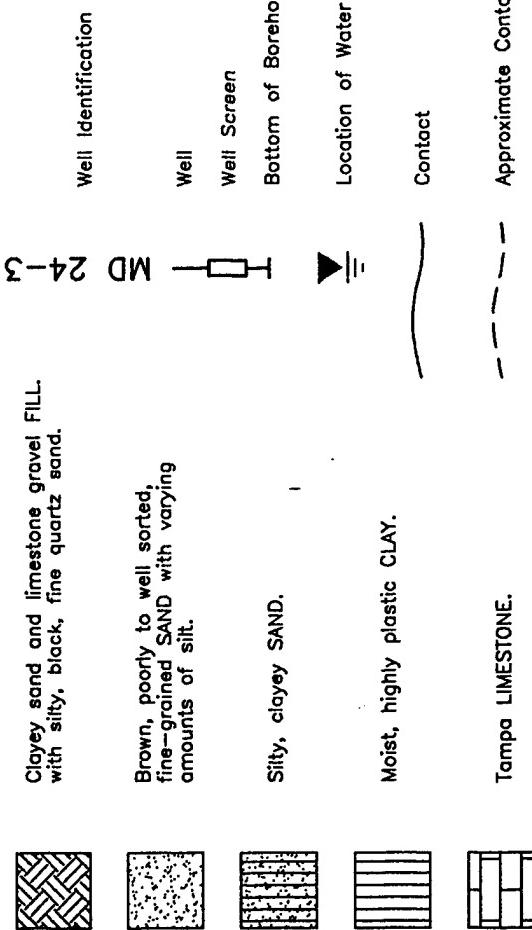


FIGURE 2.4

**HYDROGEOLOGIC
CROSS-SECTION B-B'
SITE OT-24**

Intrinsic Remediation TS
MacDill Air Force Base, Florida



Denver, Colorado

TABLE 2.1
SUMMARY OF WELL/ PIEZOMETER CONSTRUCTION DETAILS
SITE OT-24
INTRINSIC REMEDIATION TS
MACDILL AFB, FLORIDA

Well Identification	Installation Date	Well Description	Well Diameter (Inches)	Borehole Diameter (Inches)	Total Depth (Feet bgs)	Sandpack Interval (Feet bgs)	Screened Interval (Feet bgs)	Elevation TOC (Feet ngvd) ^{a/}
PW-1	7/89	Pumping	5	8	20.1	3.7-20.1	10.1-20.1	4.39
PW-3	7/89	Pumping	NR ^{b/}	NR	NR	NR	NR	8.79
PW-8	7/89	Pumping	NR	NR	NR	NR	NR	8.41
PW-10	7/89	Pumping	NR	NR	NR	NR	NR	7.92
RW-1	7/89	Recovery	6	NR	20.0	NR	NR	6.41
RW-2	7/89	Recovery	6	NR	20.0	NR	NR	6.40
OB-1	7/89	Observation	2	8	20.3	4.0-20.3	10.3-20.3	4.53
MD24-1	9/88	Monitoring	2	8	20.0	8.0-20.0	10.0-20.0	8.29
MD24-2	9/88	Monitoring	2	8	20.0	8.5-20.0	10.0-20.0	7.45
MD24-3	9/88	Monitoring	2	8	20.0	8.0-20.0	10.0-20.0	7.63
MD24-4	9/88	Monitoring	2	8	20.0	7.0-20.0	10.0-20.0	7.89
MD24-5	7/89	Monitoring	2	8	12.0	1.2-12.0	2.0-12.0	4.30
MD24-6	7/89	Monitoring	2	8	12.5	1.5-12.5	2.5-12.5	3.82
MD24-6A	7/89	Monitoring	2	NR	25.0	19.0-25.0	20.0-25.0	NR
MD24-7	7/89	Monitoring	2	8	12.2	1.2-12.2	2.2-12.2	3.40
MD24-8	7/89	Monitoring	2	8	12.2	1.5-12.2	2.2-12.2	3.76
MD24-9	7/89	Monitoring	2	8	12.2	1.7-12.2	2.2-12.2	4.02
MD24-10	7/89	Monitoring	2	8	12.3	1.3-12.3	2.3-12.3	3.11
MD24-10A	7/89	Monitoring	2	NR	29.0	23.0-29.0	24.0-29.0	NR ^{c/}
P-1	9/89	Piezometer	2	4	5.1	0.5-5.1	0.6-5.1	NA
P-2	9/89	Piezometer	2	4	5.1	0.5-5.1	0.6-5.1	NA
P-3	9/89	Piezometer	2	4	6.9	0.5-6.9	2.4-6.9	NA
P-4	9/89	Piezometer	2	4	7.6	0.5-7.6	3.1-7.6	NA
P-5	9/89	Piezometer	2	4	6.4	0.5-6.4	1.9-6.4	NA
P-6	9/89	Piezometer	2	4	5.9	0.5-5.9	1.4-5.9	NA
P-7	9/89	Piezometer	2	4	5.1	0.5-5.1	0.6-5.1	NA
P-8	9/89	Piezometer	2	4	4.0	0.5-4.0	0.5-4.0	NA
P-9	9/89	Piezometer	2	4	6.4	0.5-6.4	1.9-6.4	NA
P-10	9/89	Piezometer	2	4	5.1	0.5-5.1	0.6-5.1	NA

Source: CH2M Hill, 1991b

^{a/} TOC = top of casing; ngvd = national geodetic vertical datum.

^{b/} NR = not reported

^{c/} NA = not available

of MD 24-9, the clay unit was found at 25 feet bgs in borehole MD 24-7, possibly indicating the presence of karsting activity.

The saturated thickness of the surficial aquifer averages approximately 20 feet in the drain field area, but thickens to the northwest. Ground water is present within the sands of the surficial aquifer at depths of approximately 1 to 5 feet bgs. Ground water levels in wells at Site OT-24 were found to fluctuate an average of 3.4 feet between May and August, 1994. Ground water may be near or at the surface in some location at the site. The unpaved area east of monitoring well MD 24-5 has been submerged during periods of heavy rainfall (Figure 1.3) Table 2.2 presents a summary of ground water data for Site OT-24. Based on historic ground water elevations, flow is expected to be to the southwest (Figure 2.5). The horizontal hydraulic gradient at the site is approximately 0.003 foot/foot (ft/ft). A 48-hour aquifer pump test and slug tests indicate the hydraulic conductivity to be 11 feet per day (ft/day) and the transmissivity to be 223 square feet per day (ft^2/day) (Table B.1, Appendix B). The storage coefficient was calculated to range from 0.0015 to 0.0023 for short pumping periods, and estimated to be 0.05 to 0.1 for longer pumping times. Assuming a hydraulic conductivity of 11 ft/day, a horizontal hydraulic gradient of 0.003 ft/ft, and a porosity of 0.3, the ground water velocity is calculated to be 0.11 ft/day (CH2M Hill, 1991a).

2.1.2.2.2 Pumphouse 75 (Site 57)

As part of the site characterization effort performed by BVWS (In Preparation), 5 soil borings were completed as monitoring wells, 10 hydrocone pushes were performed, 2 piezocones soundings were completed, and 6 surface soil samples were collected in the area of Pumphouse 75. Also, 3 sediment samples were collected from a small drainage swale south of the pumphouse building (Figure 1.4). Hydrocone samples HC01 through HC08 were collected at a depth of approximately 7 feet bgs, and HC09 and HC10 were collected at 18 feet bgs. Two piezocones, PC01 and PC02, were installed to a depth of approximately 20 feet bgs to determine the depth of the clayey sand layer at Pumphouse 75. Data from piezocone sampling indicate that the sandy clay layer is found at the site at a depth of 18 to 21 feet bgs. No further geologic data are available from BVWS at this time. It is assumed that the geology at Pumphouse 75 (Site 57) is similar to that described in Section 2.1.2.2.1 for Site OT-24. Table 2.3 presents well completion and hydrocone information for Pumphouse 75 (Site 57) (BVWS, In Preparation).

In January 1994, ground water levels at Pumphouse 75 were measured by BVWS and the flow of ground water was determined to be to the southeast toward the drainage swale and the north apron of the runway (Figure 2.6). Ground water elevation data are presented in Table 2.3. The direction of ground water flow at Pumphouse 75 differs from that found at Site OT-24 due to the location of the site relative to Tampa Bay and the surface water drainage paths in the area. No information on aquifer characteristics is

TABLE 2.2
SUMMARY OF GROUND WATER LEVEL / PRODUCT THICKNESS MEASUREMENTS
SITE OT-24
INTRINSIC REMEDIATION TS
MACDILL AFB, FLORIDA

Well Identification	Total Reported Depth (Feet bgs)	Measured Depth (Feet)	Well Diameter (Inches)	Depth to Product (Feet BTOC) ^a				Depth to Water (Feet BTOC)				Product Thickness (Feet)				Water Elevation (Feet ngvd) ^c	
				9/15/89	9/20/89	10/2/89	5/23/94	8/30/94	9/15/89	9/20/89	10/2/89	5/23/94	8/30/94	9/15/89	9/20/89	10/2/89	
PW-1	20.1	NM ^b	5	NA ^e	NA	NA	-	-	NA	NA	NA	NM	0.6	NA	NA	-	NM
PW-3	NR ^d	9.28	NR	NA	NA	-	3.69	NA	NA	NA	NA	8.86	5.62	NA	NA	-	1.93
PW-8	NR	6.34	NR	NA	NA	-	-	NA	NA	NA	Dry	3.57	NA	NA	-	-	8.41
PW-10	NR	7.8	NR	NA	NA	-	-	NA	NA	NA	7	3.95	NA	NA	-	-	0.92
RW-1	20.0	NM	6	NA	NA	-	-	NA	NA	NA	5.48	1.85	NA	NA	-	-	0.93
RW-2	20.0	NM	6	NA	NA	-	1.66	NA	NA	NA	6.09	2.26	NA	NA	-	0.6	0.31
OB-1	20.3		2	NA	NA	-	-	NA	NA	NA	8	4.68	NA	NA	-	-	0.29
MD24-1	20.0	19.7	2	NA	NA	-	-	NA	NA	NA	7.12	3.23	NA	NA	-	-	0.33
MD24-2	20.0	20.11	2	NA	NA	-	-	NA	NA	NA	7.24	3.53	NA	NA	-	-	0.39
MD24-3	20.0	21.73	2	NA	NA	-	-	NA	NA	NA	7.45	3.64	NA	NA	-	-	0.44
MD24-4	20.0	20.23	2	NA	NA	-	-	NA	NA	NA	4.05	0	NA	NA	-	-	0.25
MD24-5	12.0	11.7	2	NA	NA	-	-	NA	NA	NA	3.99	0.8	NA	NA	-	-	NR
MD24-6	12.5	25.38	2	NA	NA	-	-	NA	NA	NA	3.71	0.3	NA	NA	-	-	NR
MD24-6A	29.0	11.76	2	NA	NA	-	-	NA	NA	NA	3.55	0.6	NA	NA	-	-	0.11
MD24-7	12.2	11.92	2	NA	NA	-	-	NA	NA	NA	3.91	0.6	NA	NA	-	-	-0.15
MD24-8	12.2	12.84	2	NA	NA	-	-	NA	NA	NA	3.62	0.9	NA	NA	-	-	-0.15
MD24-9	12.2	12.45	2	NA	NA	-	-	NA	NA	NA	3.12	0	NA	NA	-	-	0.4
MD24-10	12.3	12.84	2	NA	NA	-	-	NA	NA	NA	3.18	0	NA	NA	-	-	-0.11
MD24-10A	29.0	28.88	2	NA	NA	-	-	NA	NA	NA	2.29	NM	NA	NA	-	-	NR
P-1	5.1	NM	2	-	-	NM	NA	1.52	NA	NA	3.37	4.69	NA	NA	-	-	NR
P-2	5.1	NM	2	-	-	NM	NA	1.38	2.63	NM	NA	4.58	NA	NA	-	-	NR
P-3	6.9	NM	2	2.11	3.04	2.21	NA	4.1	4.94	4.28	NA	0.57	1.45	0.69	NA	NA	NA
P-4	7.6	NM	2	2.33	3.32	2.49	NA	4.9	5.72	5.11	NA	2.57	2.4	2.62	NA	NA	NA
P-5	6.4	NM	2	2.1	2.89	2.21	NA	NA	3.79	5.37	NA	1.69	2.48	2.48	NA	NA	NA
P-6	5.9	NM	2	1.76	2.52	1.46	NA	NA	3.37	4.93	NA	1.61	2.41	3.12	NA	NA	NA
P-7	5.1	NM	2	1.61	2.27	1.75	NA	2.18	3.72	2.44	NA	0.57	1.45	0.69	NA	NA	NA
P-8	4.0	NM	2	-	-	NM	NA	1.35	2.39	NM	NA	-	-	NM	NA	NA	NA
P-9	6.4	NM	2	-	-	NM	NA	2.22	2.39	NM	NA	-	-	NM	NA	NA	NA
P-10	5.1	NM	2	-	-	NM	NA	1.93	2.72	NM	NA	-	-	NM	NA	NA	NA

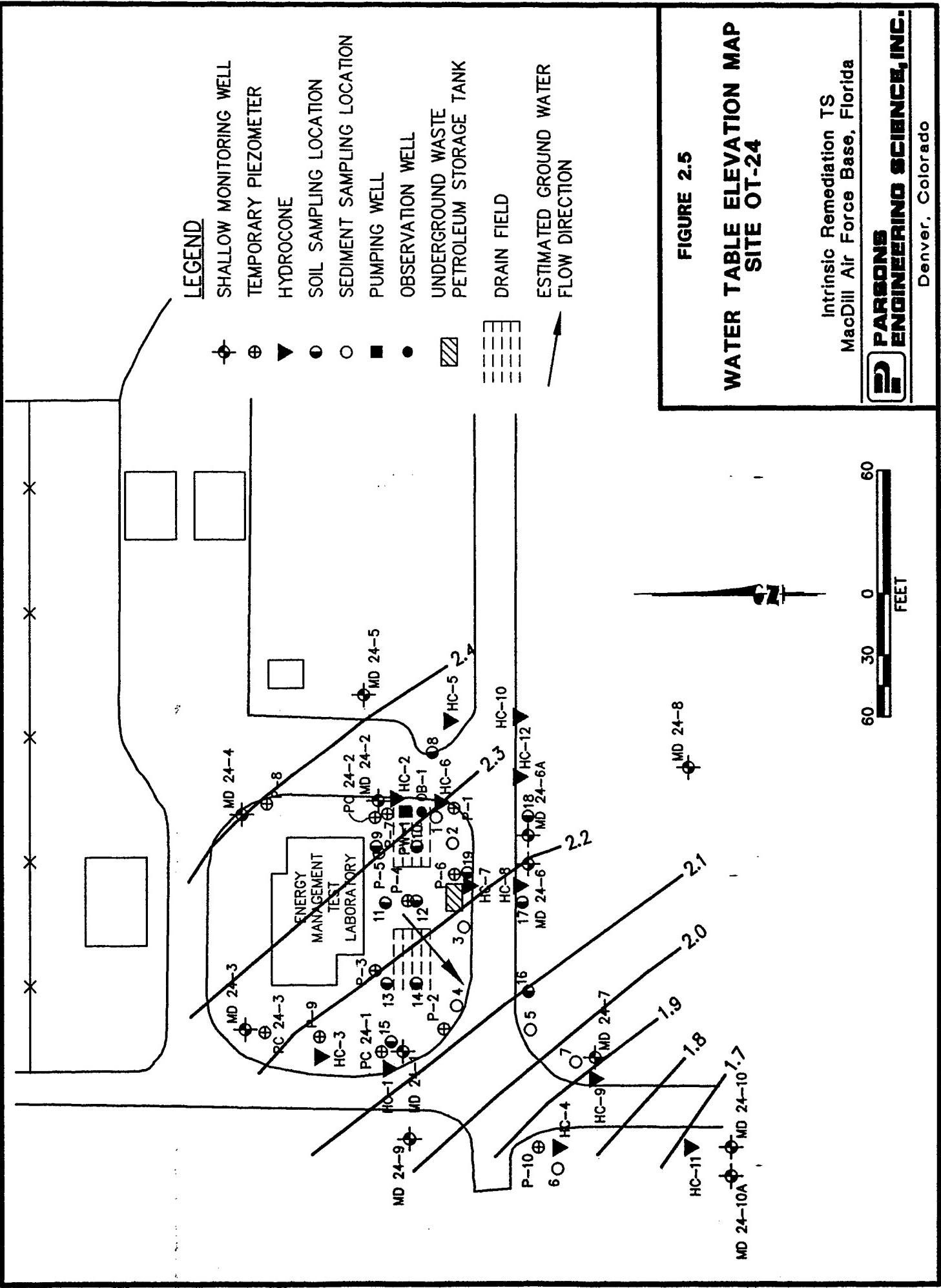
Source: CH2M Hill, 1991b

^a BTOC = Below top of casing.

^b NM = not measured

^c NM = not available

^d NA = not reported



WATER TABLE ELEVATION MAP SITE OT-24

Intrinsic Remediation TS MacDill Air Force Base, Florida

Denver, Colorado

**PARSONS
ENGINEERING**

10

Denver, Colorado

M:\45021\DRAWINGS\94DN1500.1\25\95 at 8:25

TABLE 2.3
**SUMMARY OF MONITORING WELL CONSTRUCTION AND HYDROCONE
 PUNCH DETAILS AND GROUND WATER LEVEL MEASUREMENTS
 PUMPHOUSE 75 (SITE 57)**
INTRINSIC REMEDIATION TS
MACDILL AFB, FLORIDA

Well Identification	Installation Date	Well Casing Diameter (Inches)	Total Depth (Feet bgs)	Sandpack Interval (Feet bgs)	Screen Interval (Feet bgs)	TOC Elevation (Feet msl)	Depth to Water (Feet BTOP)	Water Elevation (Feet msl)
MD75-MW01	11/4/93	2	13	1.75-13.00	2.50-11.47	8.94	3.31	5.63
MD75-MW02	11/5/94	2	14	1.67-14.00	2.42-11.39	8.12	2.75	5.37
MD75-MW03	11/5/93	2	13.5	1.75-13.50	2.50-11.48	9.31	3.72	5.59
MD75-MW04	11/4/93	2	13.5	1.75-13.50	2.50-11.48	9.07	3.4	5.67
MD75-MW05	11/5/93	2	13.5	1.75-13.50	2.50-11.48	9.5	3.68	5.82
HC-01	6-11/94	NA ^a	7	NA	NA	NA	NA	NA
HC-02	6-11/94	NA	7	NA	NA	NA	NA	NA
HC-03	6-11/94	NA	7	NA	NA	NA	NA	NA
HC-04	6-11/94	NA	7	NA	NA	NA	NA	NA
HC-05	6-11/94	NA	7	NA	NA	NA	NA	NA
HC-06	6-11/94	NA	7	NA	NA	NA	NA	NA
HC-07	6-11/94	NA	7	NA	NA	NA	NA	NA
HC-08	6-11/94	NA	7	NA	NA	NA	NA	NA
HC-09	6-11/94	NA	18	NA	NA	NA	NA	NA
HC-10	6-11/94	NA	18	NA	NA	NA	NA	NA
PC-02	6-11/94	NA	20	NA	NA	NA	NA	NA
PC-01	6-11/94	NA	21	NA	NA	NA	NA	NA

Source: BVWS, In preparation

^aNA - not applicable

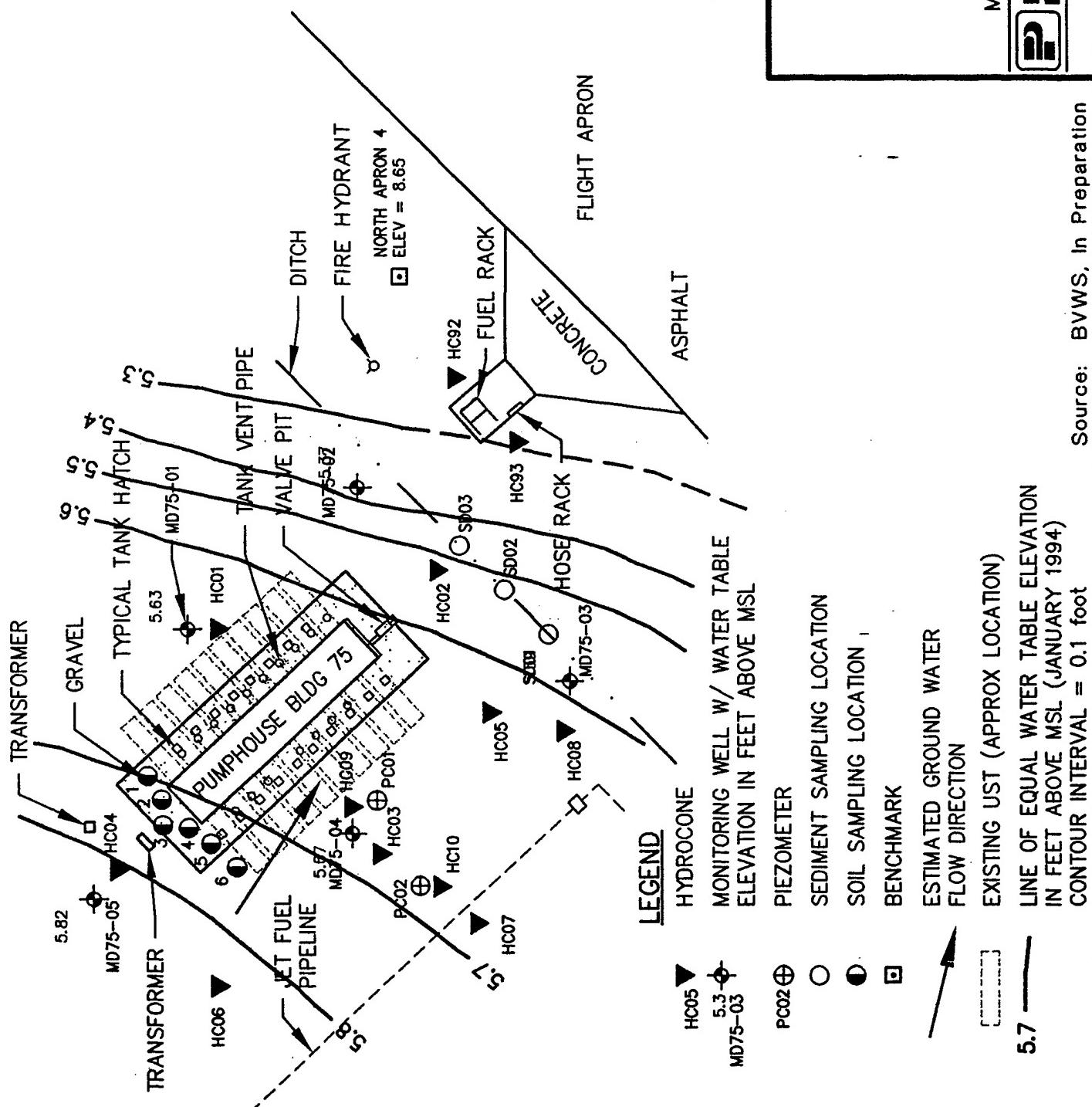


FIGURE 2.6

**WATER TABLE
ELEVATION MAP
PUMPHOUSE 75**

Intrinsic Remediation TS
MacDill Air Force Base, Florida



Denver, Colorado

Source: BVWS, In Preparation

available at this time, but it is assumed that aquifer conditions at Pumphouse 75 are similar to those found at Site OT-24.

2.1.2.2.3 Site 56

During site characterization efforts performed by BVWS (In Preparation), 7 soil borings were completed as monitoring wells, 18 hydrocone pushes were performed, and 1 piezocone was installed. Hydrocone punches MD56-HC01 through MD56-HC16 were completed to a depth of approximately 7 feet. Punches MD56-HC17 and MD56-HC18 were completed to a depth of 17 feet bgs. The piezocone was installed at a depth of approximately 20 feet bgs. The monitoring wells were installed to an approximate depth of 14 feet bgs. Table 2.4 presents monitoring well construction details. The sandy clay layer, which defines the lower extent of the surficial aquifer, was found at a depth of 17 feet bgs in the piezocone samples (PC01) (BVWS, In Preparation). No further geologic data are available at this time, but it is assumed that subsurface conditions at Site 56 are similar to those found at Site OT-24.

A ground water survey was performed by BVWS on February 1, 1994, during one tidal cycle. Tidal variations were found to have a slight effect on ground water elevations at Site 56. Ground water elevation survey results are presented in Table 2.4. A ground water elevation contour map is presented in Figure 2.7. Ground water at Site 56 was found to flow north toward a drainage ditch located adjacent to Site 32. Ground water flow direction is dependent upon the proximity of surface water pathways and the position of the site with respect to Tampa Bay. No additional hydrogeologic data are available, but aquifer characteristics at Site 56 are assumed to be comparable to those found at Site OT-24 discussed in Section 2.1.2.2.1.

2.1.3 Soil Quality

2.1.3.1 Site OT-24

Analytical results are available for soil samples collected from 3 of the 12 boreholes (labeled 8 through 19) discussed in the Section 2.1.2.2.1. In addition, 7 sediment samples (labeled 1 through 7) were taken; however, the results of the analyses for these samples are not available. Available soil analytical data are provided in Table 2.5 and are summarized on Figure 2.8.

Soil analytical data collected in June 1989, indicate that the greatest concentrations of total benzene, toluene, ethylbenzene, and xylenes (BTEX) contamination are found in the eastern drain field and extend to the southwest in the direction of ground water flow (Figure 2.8). The highest BTEX concentrations reported by the laboratory were found in the samples collected from borehole SD24-10B, adjacent

TABLE 2.4
SUMMARY OF MONITORING WELL CONSTRUCTION
DETAILS AND GROUND WATER LEVEL MEASUREMENTS
SITE 56
INTRINSIC REMEDIATIONS
MACDILL AFB, FLORIDA

Well Identification	Installation Date	Well Casing Diameter (Inches)	Total Depth (Feet bgs) ^{a/}	Sandpack Interval (Feet bgs)	Screen Interval (Feet bgs)	TOC Elevation (Feet msl) ^{b/}	Depth to Water ^{c/} (Feet msl)	Depth to Water ^{d/} (Feet BT0C)	Water Level Elevation ^{e/} (Feet msl)	Water Level Elevation ^{d/} (Feet msl)	Height of Casing Above Pad (Feet) ^{e/}	Pad Elevation (Feet msl)
MD56-MW01	10/24/93	2	13.5	1.50-13.50	2.08-11.06	6.40	3.99	3.99	2.41	2.41	-0.20	6.60
MD56-MW02	11/2/93	2	13.5	1.70-13.50	2.48-11.46	7.70	4.99	4.99	2.71	2.71	-0.22	7.92
MD56-MW03	11/2/93	2	14.0	1.50-14.00	2.44-11.36	5.89	2.96	2.96	2.90	2.93	-0.85	6.74
MD56-MW04	11/2/93	2	13.5	1.60-13.50	2.35-11.33	7.45	4.99	5.01	2.46	2.44	-0.28	7.73
MD56-MW05	11/3/93	2	13.5	1.75-13.50	2.50-11.48	6.93	4.43	4.42	2.50	2.51	-0.27	7.20
MD56-MW06	11/21/93	2	13.5	1.75-13.50	2.50-11.48	7.65	5.15	5.15	2.50	2.50	-0.21	7.86
MD56-MW07	11/21/93	2	13.5	1.75-13.50	2.50-11.48	7.38	4.87	4.88	2.51	2.50	-0.23	7.61

Source: BVWS, In preparation

^{a/} bgs - below ground surface.

^{b/} msl - mean sea level.

^{c/} Water level elevations for high tide on February 1, 1994.

^{d/} Water level elevations for low tide on February 1, 1994.

^{e/} Negative values indicate flushmount protective covers.

LEGEND

MONITORING WELL W/ WATER
TABLE ELEVATION (feet above
MSL at low tide)

HYDROCONE LOCATION

PIEZOCONE LOCATION

BENCHMARK

LINE OF EQUAL WATER TABLE ELEVATION
(feet above MSL at low tide)

ESTIMATED GROUND WATER
FLOW DIRECTION

REMOTE FILL PAD
(ABANDONED)

FUEL POINTS (TYP)



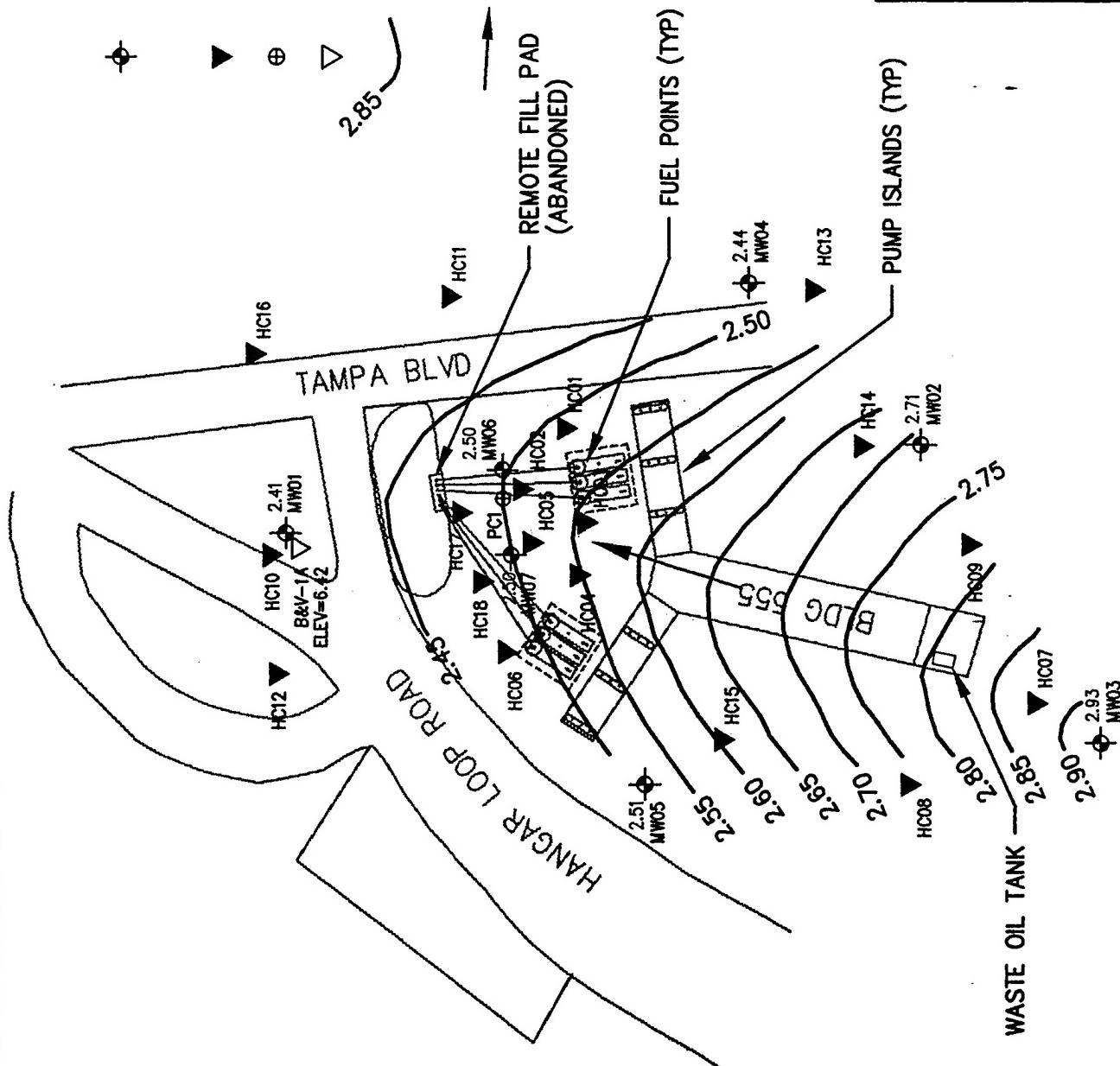
FIGURE 2.7

WATER TABLE ELEVATION MAP SITE 56

Intrinsic Remediation TS
MacDill Air Force Base, Florida

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado



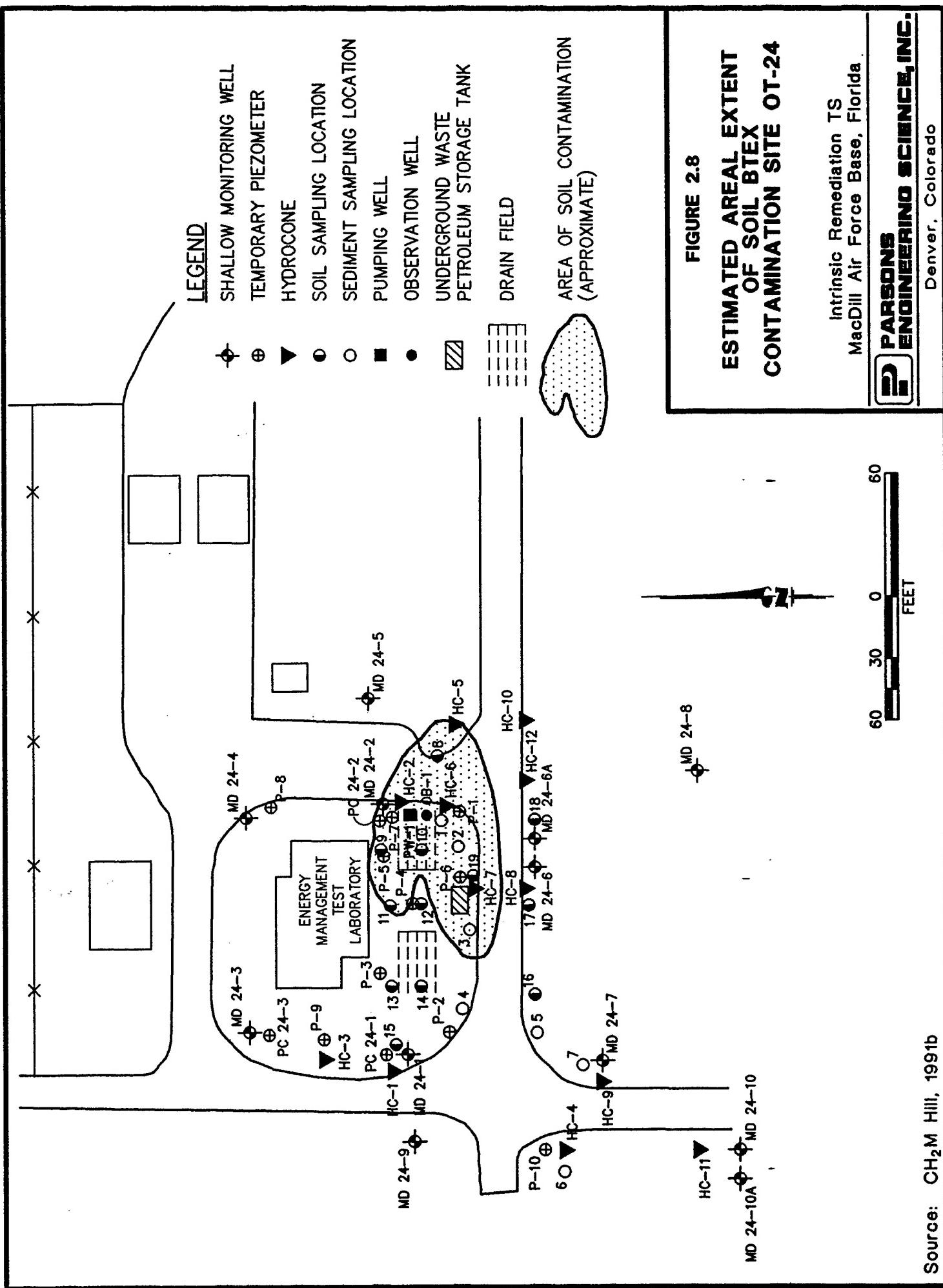
Source: BVWS, In Preparation

M:\45021\DRAWINGS\94DN1527, 1/25/95 at 9:45

TABLE 2.5
SUMMARY OF SOIL ANALYTICAL DATA
SITE OT-24
INTRINSIC REMEDIATION TS
MACDILL AFB, FLORIDA

Location	Volatile Organics EPA Method 602 (µg/kg)	Total Metals (mg/kg)	EP Toxicity (mg/kg)	Petroleum Hydrocarbons (mg/kg)
SD24-3	Ethylbenzene - 2,300 Total Xylenes - 5,800	Arsenic - 0.74 Cadmium - 3.4 Chromium - 255	Cadmium - 0.0058 Chromium - 0.033 Lead - 0.049	9,790
SD24-8B	Benzene - 210 Toluene - 400 Ethylbenzene - 3,400 Total Xylenes - 18,000	Arsenic - 0.4 Lead - 6.1		3,600
SD24-10B	Benzene - 11,000 Toluene - 360,000 Ethylbenzene - 560,000 Total Xylenes - 290,000	Arsenic - 0.85 Chromium - 10 Lead - 35		22,580
SD24-12B	Total Xylenes - 290,000	Arsenic - 0.62 Chromium - 4 Lead - 26		344

Source: CH2M Hill, 1991a



to the fuels testing laboratory in the eastern drain field. Approximately 122,100 micrograms per kilogram ($\mu\text{g}/\text{kg}$) of total BTEX and 9,790,000 $\mu\text{g}/\text{kg}$ of total recoverable petroleum hydrocarbons (TRPH) were found in the 1-foot bgs sample. Elevated total BTEX levels also were identified in borehole SD24-8B, SD24-3, and SD24-12B (22,010 $\mu\text{g}/\text{kg}$, 8,100 $\mu\text{g}/\text{kg}$, and 610 $\mu\text{g}/\text{kg}$, respectively) (CH2M Hill, 1990 and 1991a).

Results of an organic vapor analyzer (OVA) screening performed during site assessment activities in June 1989 confirmed the presence of elevated volatile organic compound (VOC) levels in the eastern drain field. Table 2.6 presents OVA readings from soil borings performed in 1989. OVA readings of 10,000 parts per million, volume per volume (ppmv) or greater were obtained in samples 1, 8, 9, 10, 11, and 19. Elevated OVA readings were also seen in samples 2, 3, 12, and 16 (5500 ppmv, 5000 ppmv, 800 ppmv, and 100 ppmv, respectively). Soil sampling locations are shown on Figure 2.8. OVA sampling results also indicate that depth of maximum concentration increases with distance from the eastern drain field (CH2M Hill, 1990 and 1991a).

2.1.3.2 Pumphouse 75 (Site 57)

Soil headspace screening was performed at 207 locations at Pumphouse 75 to delineate the extent of soil contamination. Table 2.7 presents a summary of headspace screening results and Figure 2.9 shows headspace sampling locations. Figure 2.9 also shows the approximate areal extent of contaminated soil with greater than 50 ppm concentrations of mixed product. Elevated hydrocarbon concentrations were identified adjacent to Pumphouse 75, along the jet fuel pipeline to the west of the pumphouse, and in a drainage ditch located south of the pumphouse building.

Soil samples were collected for laboratory analysis during the boring of the five monitoring wells installed by BVWS (Section 2.1.2.2.2). A summary of laboratory analytical results of soil samples for Pumphouse 75 (Site 57) are presented in Table 2.8. Laboratory analyses indicate that the greatest concentrations of contaminants were present in soils associated with MD 75-01. A total BTEX concentration of 114,870 $\mu\text{g}/\text{kg}$ and a TRPH concentration of 33,000 $\mu\text{g}/\text{kg}$ were identified in the 2- to 3-foot bgs sample. Contamination extends to the southeast from MD75-01 in the direction of ground water flow. The estimated areal extent and concentrations of contaminants are shown in Figure 2.10. Soil samples taken from the other four monitoring wells showed total BTEX concentrations below 10 $\mu\text{g}/\text{kg}$, and TRPH levels of 20 $\mu\text{g}/\text{kg}$ or less. Surface soil samples collected at MD75-01 and MD75-04 and the 2- to 3-foot sample from MW04 showed high concentrations of naphthalene, acenaphthylene, and/or acenaphthalene (BVWS, In Preparation).

Six surface soil samples were collected in areas adjacent to the control room and analyzed for PCBs (Figure 2.10). PCBs were detected in the highest concentrations in sample SS01 (2,300 $\mu\text{g}/\text{kg}$), collected on the northeast side of the control room. Samples

TABLE 2.6
SUMMARY OF SOIL ORGANIC VAPOR ANALYZER DATA FOR JUNE 1989^{a/}
SITE OT-24
INTRINSIC REMEDIATION TS
MACDILL AFB, FLORIDA

Sample #	A (0-1 ft bgs)	B (1-2 ft bgs)	C (2-3 ft bgs)
1	>10,000	-- ^{b/}	--
2	5,500	--	--
3	5,000	--	--
4	10	--	--
5	11	--	--
6	<10	--	--
7	<10	--	--
8	15	>10,000	>10,000
9	>10,000	--	--
10	>10,000	>10,000	--
11	10	10,000	--
12	<10	800	--
13	<10	--	--
14	<10	<10	--
15	<10	<10	<10
16	<10	<10	100
17	<10	<10	20
18	<10	<10	--
19	550	10,000	>10,000

Source: CH2M Hill, 1991b

^{a/} Results are expressed in ppmv.

^{b/} -- = Sample not collected.

TABLE 2.7
SOIL HEADSPACE READINGS FOR DECEMBER 1993
PUMPHOUSE 75 (SITE 57)
INTRINSIC REMEDIATION TS
MACDILL AFB, FLORIDA

Boring No.	W/O Filter	W Filter	Hydrocarbons
1	0	NC	0
2	0	NC	0
3	0	NC	0
4	0	NC	0
5	0.5	NC	0.5
6	0	NC	0
7	0	NC	0
8	0	NC	0
9	0	NC	0
10	0	NC	0
11	0	NC	0
12	0	NC	0
13	>1000	>1000	?
14	0	NC	0
15	12	NC	12
16	82	88	0
17	1	NC	1
18	5	2	3
19	0	NC	0
20	0	NC	0
21	0	NC	0
22	110	50	60
23	320	50	270
24	>1000	150	>850
25	1	NC	1
26	0	NC	0
27	0	NC	0
28	0	NC	0
29	0.2	NC	0.2
30	0.1	NC	0.1
31	1	NC	1
32	0	NC	0
33	>1000	NC	>1000
34	200	NC	200
35	70	4	66
36	>1000	110	>890
37	>1000	70	>930
38	>1000	120	>880
39	500	30	470
40	4	NC	4
41	900	55	845
42	10	NC	10
43	>1000	250	>750
44	120	50	70
45	>1000	70	>930
46	>1000	90	>910
47	>1000	130	>870
48	>1000	68	>932
49	>1000	350	>650
50	>1000	74	>926
51	12	NC	12
52	>1000	20	>980
53	>1000	120	>880
54	>1000	25	>975
55	360	8	352
56	0.8	NC	0.8
57	0	NC	0
58	>1000	12	>988
59	0	NC	0
60	5	NC	5
61	>1000	600	>400
62	1.1	0.6	0.5
63	>1000	160	>840
64	20	NC	20
65	1.6	NC	1.6
66	>1000	>1000	?
67	>1000	>1000	?
68	>1000	92	>918
69	>1000	105	>895

#NAME?

Boring No.	W/O Filter	W Filter	Hydrocarbons
70	>1000	800	200
71	0.1	NC	0.1
72	0.5	NC	0.5
73	>1000	>1000	?
74	0	0	0
75	150	65	85
76	700	520	180
77	>1000	700	>300
78	>1000	>1000	?
79	400	NC	400
80	>1000	NC	>1000
81	>1000	NC	>1000
82	350	NC	350
83	55	NC	55
84	0.7	NC	0.7
85	>1000	NC	>1000
86	0.2	NC	0.2
87	0.15	NC	0.15
88	0.2	NC	0.2
89	0.8	NC	0.8
90	600	250	350
91	>1000	550	>450
92	>1000	NC	>1000
93	>1000	NC	>100
94	>1000	700	>300
95	>1000	920	>80
96	>1000	>1000	?
97	>1000	980	>20
98	>1000	>1000	?
99	>1000	NC	>1000
100	>1000	NC	>1000
101	>1000	NC	>1000
102	>1000	>1000	?
103	>1000	>1000	?
104	>1000	>1000	?
105	1	NC	1
106	0.9	NC	0.9
107	0.3	NC	0.3
108	>1000	120	>880
109	>1000	>1000	?
110	>1000	340	>660
111	>1000	360	>640
112	120	0	120
113	>1000	>1000	?
114	>1000	>1000	?
115	>1000	>1000	?
116	>1000	0	>1000
117	>1000	0	>1000
118	>1000	0	>1000
119	0	NC	0
120	0	NC	0
121	>1000	0	>1000
122	400	0	400
123	>1000	0	>1000
124	>1000	0	>1000
125	0	?	0
126	0	0	0
127	50	40	10
128	>1000	0	>1000
129	>1000	0	>1000
130	60	15	45
131	>1000	0	>1000
132	800	0	800
133	600	100	500
134	>1000	200	>800
135	>1000	200	>800
136	800	400	400
137	0	NC	0
138	0	NC	0

Boring No.	W/O Filter	W Filter	Hydrocarbons
139	0	NC	0
140	250	0	250
141	200	0	200
142	200	0	200
143	0	NC	0
144	4	NC	4
145	0	NC	0
146	>1000	>1000	?
147	0	NC	0
148	0	NC	0
149	0	NC	0
150	>1000	45	>955
151	350	NC	350
152	1.5	NC	1.5
153	2.2	NC	2.2
154	0.2	NC	0.2
155	0	NC	0
156	>1000	600	>400
157	1.4	NC	1.4
158	640	260	380
159	0	NC	0
160	0	NC	0
161	300	50	250
162	280	6	274
163	1.4	0.8	0.6
164	>1000	260	>740
165	>1000	900	>100
166	550	62	488
167	72	50	22
168	0.2	0	0.2
169	520	40	480
170	140	54	86
171	22	4.6	17.4
172	>1000	400	>600
173	650	NC	650
174	440	50	390
175	0.4	NC	0.4
176	0.4	NC	0.4
177	320	140	180
178	0.2	NC	0.2
179	0.6	NC	0.6
180	NC	NC	NC
181	>1000	400	>600
182	560	260	300
183	560	170	390
184	2.2	NC	2.2
185	620	230	390
186	3.6	2.8	0.8
187	192	72	120
188	1	0.8	0.2
189	0.6	0	0.6
190	45	10	35
191	NC	NC	NC
192	0.4	NC	0.4
193	12	NC	12
194	400	NC	400
195	72	14	58
196	0.4	0.2	0.2
197	0	0.2	0
198	2.6	NC	2.6
199	280	NC	280
200	6.2	4	2.2
201	35	5	30
202	2	2	0
203	>1000	400	>600
204	0	NC	0
205	80	8	72
206	0	0.2	0
207	0	NC	0

FIGURE 2.9

**SOIL VOC HEADSPACE
SCREENING & ISOPLET MAP
PUMPHOUSE 75**

Intrinsic Remediation TS
MacDill Air Force Base, Florida



Denver, Colorado
2-22

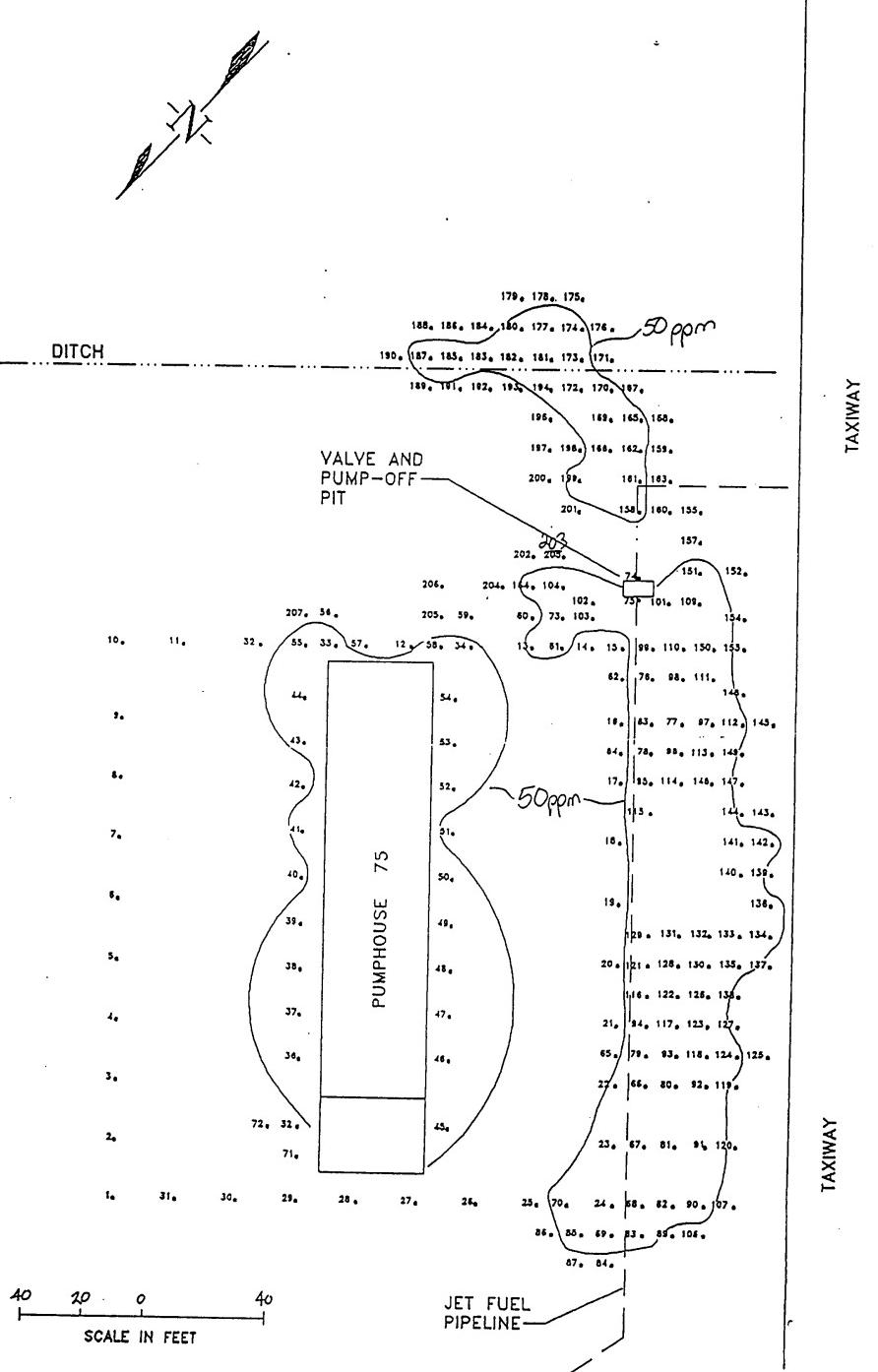


TABLE 2.8
SUMMARY OF SEDIMENT/SOIL ANALYTICAL DATA
PUMPHOUSE 75 (SITE 57)
INTRINSIC REMEDIATION TS
MACDILL AFB, FLORIDA

Parameter	Sampling Location												
	SD01	SD02	SD03	MW01 0-1	MW01 2-3	MW02 0-1	MW02 2-3	MW03 0-1	MW03 2-3	MW04 0-1	MW04 2-3	MW05 0-1	MW05 2-3
Halogenated Organics ug/kg (8010)													
Methylene Chloride	2.9B	1.5B	.6JB	3.3B	-	12.6B	6.0B	4.5B	10.8B	4.4B	6.6B	4.3B	5.3B
Tetrachloroethene	0.7J	0.7J	-	NA									
1,3 Dichlorobenzene	0.6J	-	-	NA									
Trichlorofluoromethane	-	1.3	1.0J	-	-	0.9J	-	-	-	-	-	-	-
Chlorobenzene	NA	NA	NA	-	-	0.6J	-	-	-	-	-	-	-
1,1 Dichlorethane	NA	NA	NA	-	-	-	-	1.2	-	-	-	-	1.3
Total Volatile Organic Hydrocarbons	4.2	3.5	1.6	3.3	-	14.1	6	5.7	10.8	4.4	6.6	4.3	6.6
Aromatic Organics ug/kg (8020)													
Benzene	NA	NA	NA	-	2,850	-	-	-	-	-	-	-	-
Toluene	NA	NA	NA	-	19,600	7.2	0.9J	2	-	1.2	-	2.5	0.8J
Ethylbenzene	NA	NA	NA	4.4J	72,200	-	-	-	-	-	-	-	-
Total Xylenes	1.2	0.6J	-	10.0J	85,200	-	-	-	-	-	-	-	-
Total BTEX	1.2	0.6	-	14.4	114,870	7.2	0.9	2	-	1.2	-	2.5	0.8
Total Volatile Organic Aromatics	1.2	0.6	-	14.4	114,870	7.2	0.9	2	-	1.2	-	2.5	0.8
PAHs ug/kg (8100)													
Naphthalene	NA	NA	NA	31J	-	-	-	-	-	152	-	-	-
Acenaphthylene	NA	NA	NA	186	-	-	-	-	-	168	-	-	-
Acenaphthene	NA	NA	NA	-	-	-	-	-	-	134	97	-	-
Phenanthrene	364	190	133	NA									
Fluoranthene	929	879	529	-	-	-	-	-	-	124	-	-	-
Pyrene	929	972	510	-	-	-	-	-	-	127	-	-	-
Benzo(a)anthracene	345	646	450	NA									
Chrysene	717	735	388	NA									
Benzo(b/k)fluoranthene	1100	1040	576	NA									
Benzo(a)pyrene	188	194	-	NA									
Dibenz(ah)anthracene/Indeno(123-cd)pyrene	319	-	-	NA									
Benzo(ghi)perylene	554	1,720	909	132	-	-	-	-	-	262	-	-	-
Total PAHs	5,445	6,376	3,495	349	-	-	-	-	-	967	97	-	-
TRPH mg/kg (418.1)													
	69,000	-	-	14	33,000	20	-	-	-	-	-	-	-
RCRA Metals mg/kg													
Barium	8.3	14.5	8.4	9.8	9	5.5	2.8	3.7	5.5	8.7	5	8.2	3.2
Cadmium	-	0.85	0.36	NA		NA							
Chromium	3.5	12.8	6.9	5.8B	5.3B	3.8B	2.7B	3.0B	6.8B	4.8B	3.1B	4.6B	3.8B
Lead	9.5	110	49	4.4	3	5	1.9	3	1.8	2.8	1.4	7	0.8
Mercury	NA	NA	NA	-	0	-	-	-	0.129	-	-	-	-

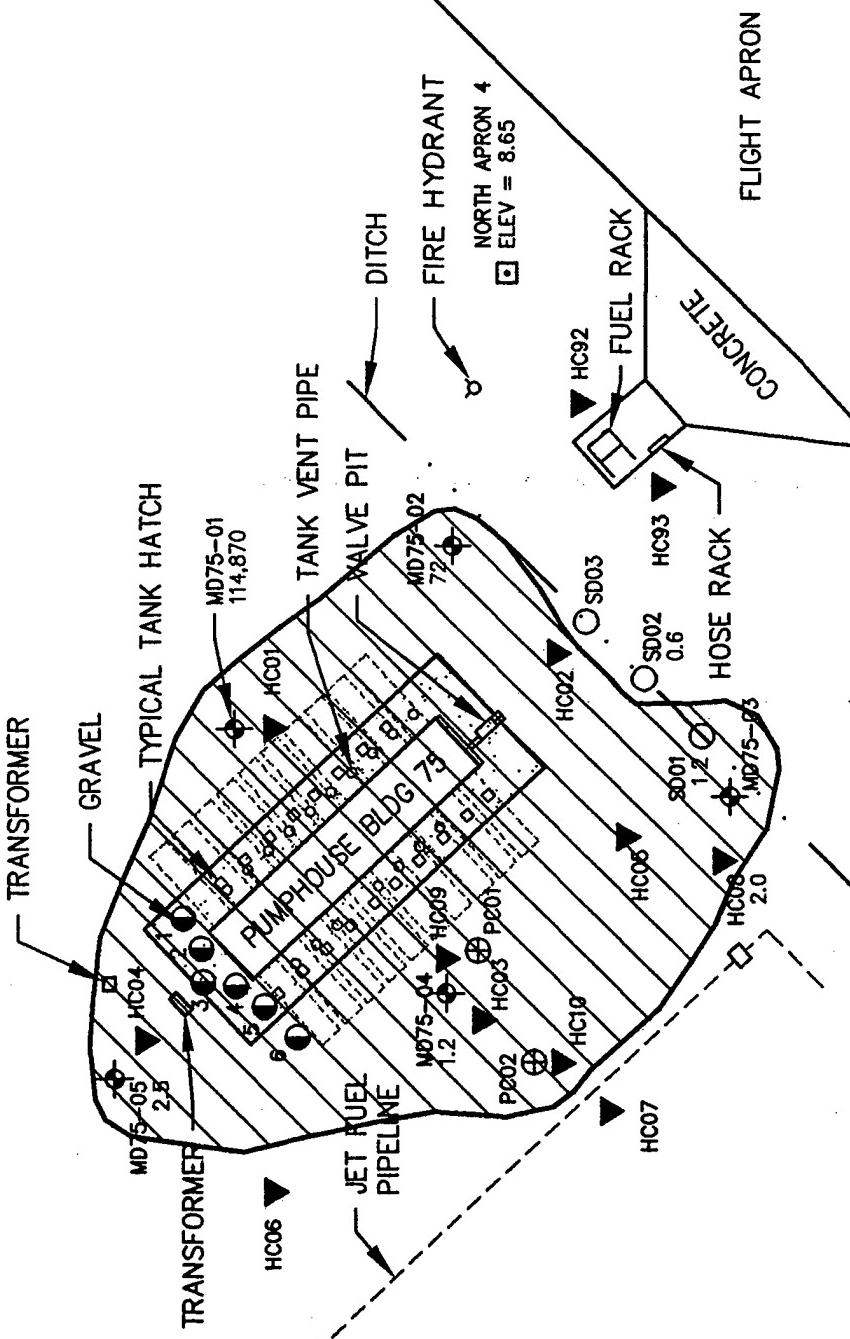
Source: BVWS, In Preparation

- = not detected

NA = not analyzed for

B = analyte was detected in blank as well as sample

J = estimated value



100
50 0 FEET

FIGURE 2.10

**ESTIMATED AREAL EXTENT
OF SOIL BTEX CONTAMINATION
PUMPHOUSE 75**

Intrinsic Remediation TS
MacDill Air Force Base, Florida

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

Source: BVWS, In Preparation

SS02, SS04, and SS05 also exhibited high levels of PCBs, containing 870 µg/kg, 250µg/kg, and 180 µg/kg, respectively (BVWS, In Preparation). A summary of laboratory analytical results for PCB contamination is presented in Table B.3 in Appendix B.

Three sediment samples were collected from a drainage swale to the southeast of Pumphouse 75. The drainage ditch is small and flows to the northeast (Figure 2.10). Only SD01 (1.2 µg/kg of total BTEX) contained total BTEX concentrations above 1 µg/kg (Table 2.8). All three sediment samples, however, contained total polynuclear aromatic hydrocarbon (PAH) concentrations greater than 3,000 µg/kg. The high PAH levels in the drainage swale are possibly attributable to jet exhaust as a result of the close proximity of Pumphouse 75 to the north apron of the flightline. Elevated TRPH concentrations found in SD01 (69,000 µg/kg) are attributed to runoff from the taxiway adjacent to Pumphouse 75 (BVWS, In Preparation).

2.1.3.3 Site 56

Soil headspace screening performed at 55 locations at Site 56 indicated that the highest contaminant concentrations were found to the north and east of USTs 4, 5, and 6, near the remote fill pad, and downgradient of the fuel lines associated with USTs 1, 2, and 3. Table 2.9 presents the results of headspace screening at Site 56, and Figure 2.11 shows the headspace screening locations and a 500-ppmv contamination concentration contour derived from the headspace data.

Results from the seven soil samples associated with the monitoring well discussed in Section 2.1.2.2.3 (see Table 2.10) indicate that maximum BTEX contamination concentrations in the soil are found in the area of monitoring well MD56-MW07 (1,260,300 µg/kg), near the remote fuel pad. Monitoring well MD56-MW06, also near the remote fuel pad, contained a soil BTEX concentration of 1,251,300 µg/kg. Both MD56-MW06 and MD56-MW07 showed maximum BTEX concentrations in samples taken at 2 to 3 feet bgs. The remaining five monitoring wells at Site 56 contained BTEX contamination, but concentrations were below 10 µg/kg. Figure 2.12 shows the estimated areal extent of soil BTEX contamination at Site 56. In addition, elevated concentration of naphthalene were found in MD56-MW06 and MD56-MW07 (305,474 µg/kg and 45,805 µg/kg, respectively), with naphthalene being the only PAH constituent identified (BVWS, In Preparation).

TABLE 2.9
SOIL HEADSPACE READINGS FOR FEBRUARY 1994
SITE 56
INTRINSIC REMEDIATION TS
MACDILL AFB, FLORIDA

Boring No.	W/O Filter (ppmv)	W Filter (ppmv)	Hydrocarbons (ppmv)
1	550	22	528
2	975	40	935
3	50	0	50
4	225	10	215
5	>10,000	17	>9,983
6	400	15	385
7	9,500	12	9,488
8	17	0	17
9	0	0	0
10	0	0	0
11	20	0	20
12	>10,000	20	>9,980
13	2,300	0	2,300
14	>10,000	20	>9,800
15	0	0	0
16	0	0	0
17	0	0	0
18	25	0	25
19	8,500	5	8,495
20	170	3	167
21	800	20	780
22	6,700	8	6,692
23	8	0	8
24	3	0	3
25	7,000	20	6,980
26	>10,000	8	>9,992
27	3	0	3
28	0	0	0
29	0	0	0
30	0	0	0
31	0	0	0
32	0	0	0
33	125	3	122
34	0	0	0
35	1,000	0	1,000
36	0	0	0
37	0	0	0
38	0	0	0
39	>10,000	28	>9,972
40	100	0	100
41	0	0	0
42	570	30	540
43	200	0	200
44	10,000	220	9,780
45	175	10	165
46	1,100	20	1,080
47	120	5	115
48	150	5	145
49	5	0	5
50	0	0	0
51	0	0	0
52	0	0	0
53	0	0	0
W.O.1	0	0	0
W.O.2	0	0	0

Source: BVWS In Preparation

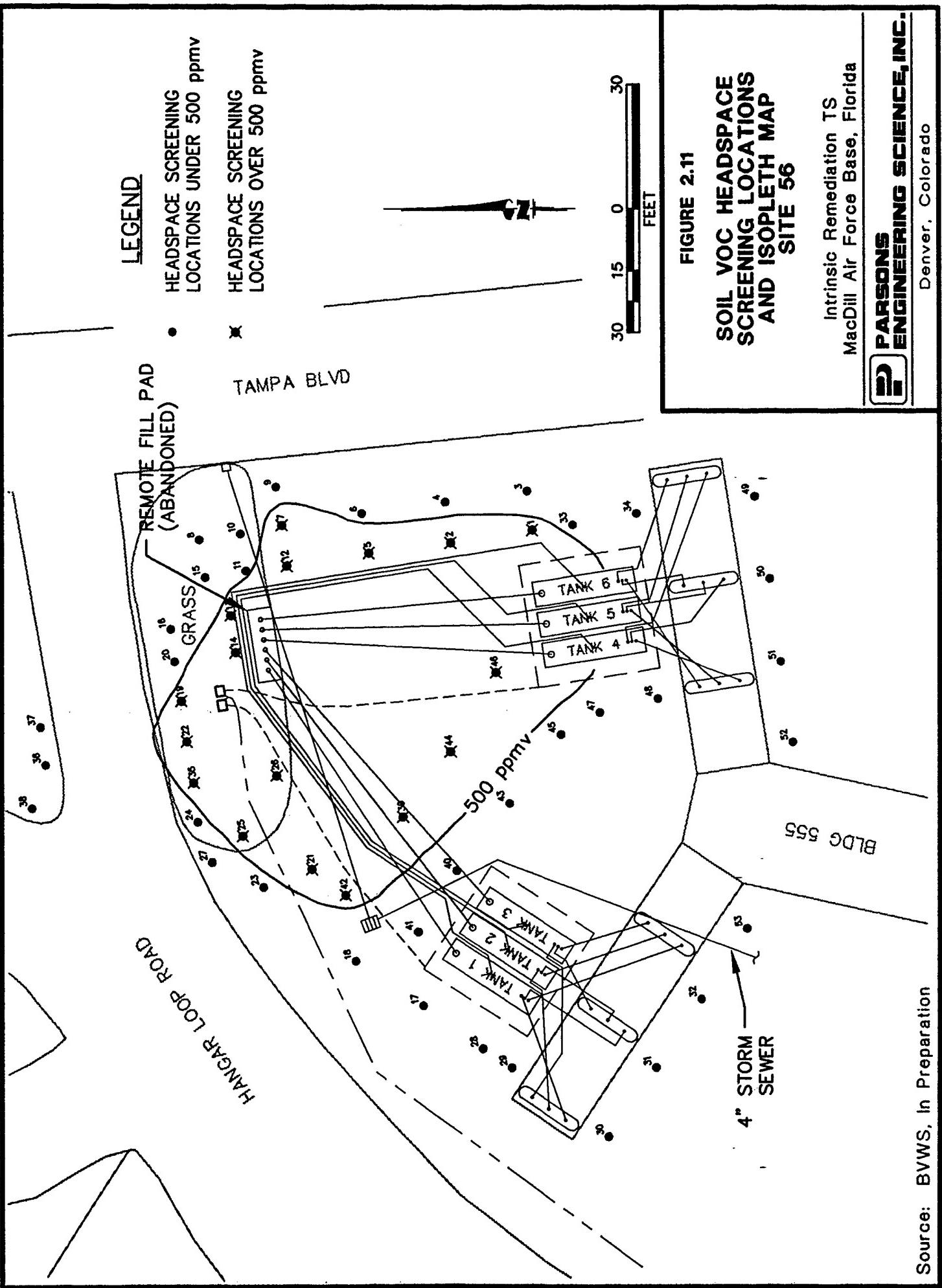


TABLE 2.10
SUMMARY OF SOIL ANALYTICAL DATA
SITE 56
INTRINSIC REMEDIATION TS
MACDILL AFB, FLORIDA

Parameter	Sampling Location													
	MW01 0-1	MW01 2-3	MW02 0-1	MW02 2-3	MW03 0-1	MW03 2-3	MW04 0-1	MW04 2-3	MW05 0-1	MW05 2-3	MW06 0-1	MW06 2-3	MW07 0-1	MW07 2-3
Halogenated Volatile organics ug/kg (8010)														
Methylene Chloride	11.3B	22.8B	X	X	6.9B	13.1B	6.2B	6.7B	6.3B	6.9B	-	-	-	-
Tetrachloroethene	-	0.7J	X	X	-	-	-	-	-	-	-	-	-	-
Trichlorofluoromethane	-	6.3	X	X	-	-	-	-	-	-	-	-	-	-
1,1 Dichlorethene	0.9J	0.8J	X	X	-	-	-	-	-	-	-	-	-	-
Total VOH	12.2	25.6	X	X	6.9B	13.1B	6.2B	6.7B	6.3B	6.9B	-	-	-	-
Aromatic Volatile organics ug/kg (8020)														
Benzene	-	-	X	X	-	-	-	-	-	-	21,000	35,300	-	22,300
Toluene	0.5J	5.7	X	X	2.5	7.7	1.4	1.4	0.9J	4.4	194,000	250,000	14,600	182,000
Ethylbenzene	-	-	X	X	-	-	-	-	-	-	118,000	318,000	176,000	332,000
Total Xylenes	-	-	X	X	1.2	1.2	1.7	-	-	-	583,000	648,000	140,000	724,000
Total BTEX	0.5J	5.7	1.1J	8	3.7	8.9	3.1	1.4	0.9J	4.4	916,000	1,251,300	172,200	1,260,300
Total VOA	0.5J	5.7	X	X	3.7	8.9	3.1	1.4	0.9J	4.4	916,000	1,262,200	172,200	1,268,831
Halogenated Organic Compounds ug/kg (8240)														
Ethylene Chloride	X	X	8.8	11	X	X	X	X	X	X	X	X	X	X
Tetrachlorethane	X	X	-	7	X	X	X	X	X	X	X	X	X	X
Toluene	X	X	1.1J	8	X	X	X	X	X	X	X	X	X	X
Total VOH	X	X	8.8	18	X	X	X	X	X	X	X	X	X	X
Total VOA	X	X	1.1	8.3	X	X	X	X	X	X	X	X	X	X
PAHs ug/kg (8100)														
Phthalene	-	-	X	X	-	-	-	-	-	-	28,473	305,474	21,182	45,805
acenaphthylene	-	-	X	X	-	-	-	-	-	-	98	-	-	-
Acenaphthene	-	-	X	X	-	-	-	-	-	-	53	-	-	-
Phenanthrene	41	-	X	X	-	-	-	-	-	-	966	-	-	2,439
Quoranthene	90	243	X	X	289	-	-	-	105	930	-	-	4,466	-
Terrene	78	132	X	X	138	-	-	-	-	-	1870	1,525	-	5,190
Benzo(a)anthracene	-	-	X	X	-	-	-	-	-	-	-	-	-	1,657
Chrysene	107	-	X	X	-	-	-	-	-	-	-	-	-	3,750
Benzo(b/k)fluoranthene	-	-	X	X	-	-	-	-	-	-	-	-	-	4,967
Benzo(a)pyrene	80	46	X	X	-	-	-	-	-	-	-	-	-	757
benz(ah)anthracene/Indeno(123-cd)pyrene	159	-	X	X	-	704	1060	486	-	-	-	-	-	-
Total PAHs	465	405	X	X	427	704	1060	486	105	4033	29,998	305,474	444,408	45,805
RPH mg/kg (418.1)														
	-	-	40	10	58	-	-	-	-	59	940	2,600	430	1,600
RCRA Metals mg/kg														
Barium	X	X	7.7	1.7	X	X	X	X	X	X	X	X	X	X
Cromium	X	X	3.5	2.60	X	X	X	X	X	X	X	X	X	X
Lead	7.0	2.3	1.8	3.4	30.8	-	10.6	2.0	10.0	6.5	332.0	8.1	58.5	21.1

Source: BVWS, In Preparation.

= not detected.

A = not analyzed for.

B = analyte was detected in laboratory method blank as well as sample.

J = estimated value.

=sample not analyzed by the method listed.

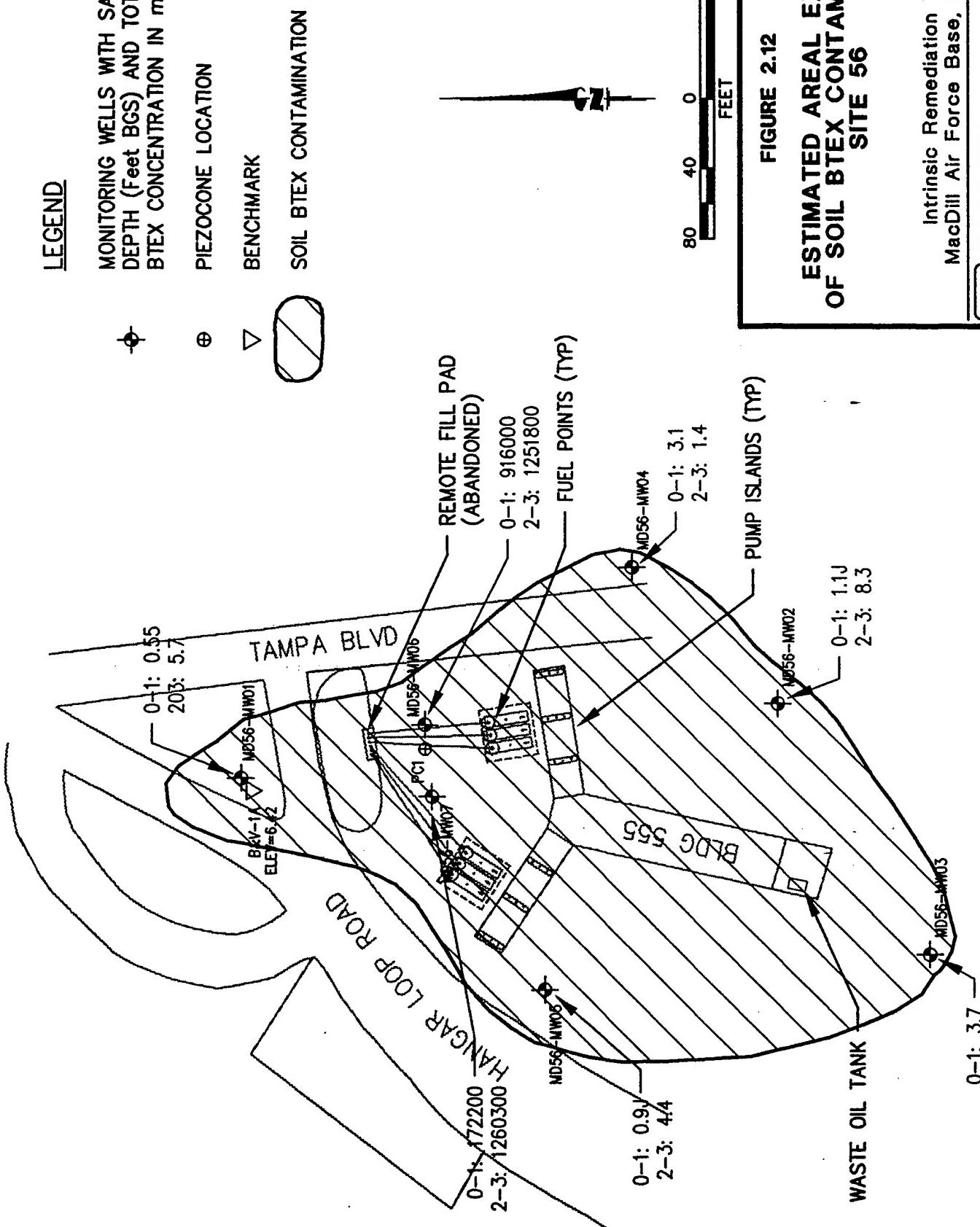


FIGURE 2.12

ESTIMATED AREAL EXTENT OF SOIL BTEX CONTAMINATION SITE 56

Intrinsic Remediation TS
MacDill Air Force Base, Florida

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

Source: BVWS, In Preparation

M:\45021\DRAWINGS\94DN1527, 1/25/95 at 9:10

2.1.4 Ground Water Quality and Chemistry

2.1.3.1 Site OT-24

Ground water analytical results are available for the hydrocone samples and the 12 site monitoring wells. Hydrocone samples collected in May 1989 were analyzed for chlorinated compounds. Results of the analyses are presented in Table 2.11. Ground water samples from the monitoring wells were collected in August 1989, August 1990, October 1990, May 1994, and August 1994. In addition, sampling events occurred for monitoring well MD 24-1 through MD 24-4 in December 1988 and May 1989. The assembled results from these sampling events are provided in Table 2.12.

Assuming a southwesterly flow of ground water, ground water contamination at Site OT-24 originates in the area adjacent to the Fuels Management Test Laboratory and extends southwestward. The results of ground water sample laboratory analyses indicate that the dissolved hydrocarbon plume has decreased in size as well as concentration. In 1989, the dissolved BTEX plume extended from the Energy Management Test Laboratory downgradient to near MD 24-7 and covered an estimated 20,000 square ft (ft^2). Figure 2.13 shows the estimated areal extent of BTEX in the ground water in 1989, and Figure 2.14 indicates the estimated areal extent of BTEX contamination in 1994. In 1994, the dissolved plume was estimated to cover 10,000 ft^2 and extend from the laboratory building downgradient to near the location of soil sample 16, representing a reduction in area of approximately 10,000 ft^2 between 1989 and 1994, and a contraction of approximately 55 feet in the leading edge of the BTEX plume (CH2M Hill, 1990 and 1991a).

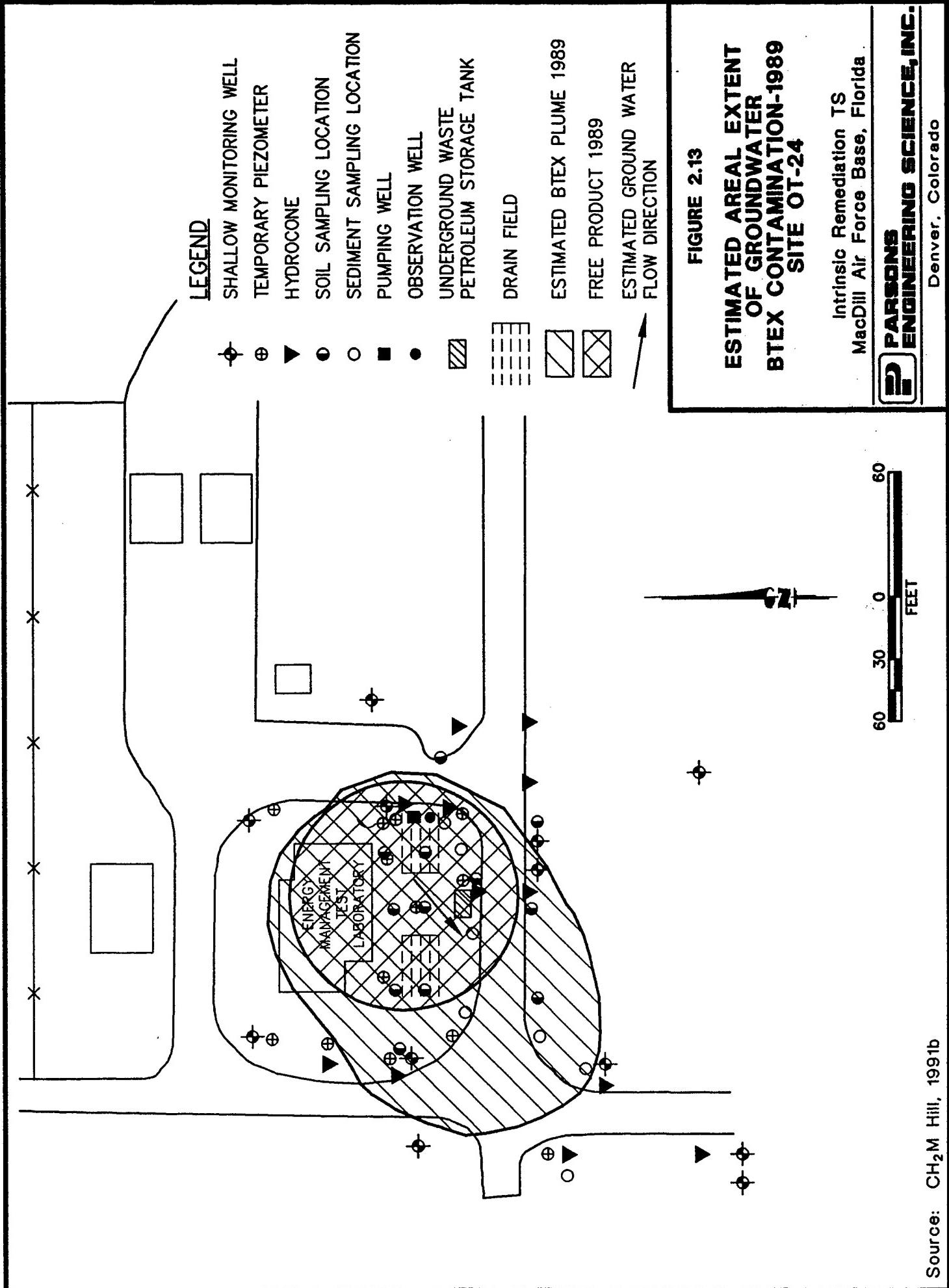
The maximum total BTEX concentration in samples collected in 1989 was 172 micrograms per liter ($\mu\text{g/L}$) found in MD 24-1. BTEX contamination was also found in monitoring wells MD 24-2 (43 $\mu\text{g/L}$) and MD 24-6 (120 $\mu\text{g/L}$) in 1989. The 1990 sampling event identified dissolved BTEX constituents in monitoring wells MD 24-6A (33 $\mu\text{g/L}$) and MD 24-3 (2 $\mu\text{g/L}$). In 1994, the maximum total BTEX concentration of 160 $\mu\text{g/L}$ was found in monitoring well MD 24-6. Significant total BTEX concentrations were also identified in MD 24-2 (91.5 $\mu\text{g/L}$) and MD 24-6A (23 $\mu\text{g/L}$) in May 1994. Total BTEX concentrations in MD 24-1 decreased to less than 1 $\mu\text{g/L}$ in 1994. Likewise, total BTEX concentrations in monitoring wells MD 24-6A and MD 24-7 decreased 13 $\mu\text{g/L}$ and 2 $\mu\text{g/L}$, respectively, between 1989 and 1994. In other monitoring wells, however, total BTEX concentrations increased in the period between 1989 and 1994. Monitoring well MD 24-2 and MD 24-6 showed increases of 14.5 $\mu\text{g/L}$ and 40 $\mu\text{g/L}$, respectively. In addition, inconsistent ground water analytical data exists for Site OT-24. Monitoring wells MD 24-6 showed a 160 $\mu\text{g/L}$ decrease in total BTEX concentration between May and August 1994 and total BTEX concentration levels in MD 24-3 dropped 52 $\mu\text{g/L}$ during the same time period. Total BTEX concentrations in samples taken from

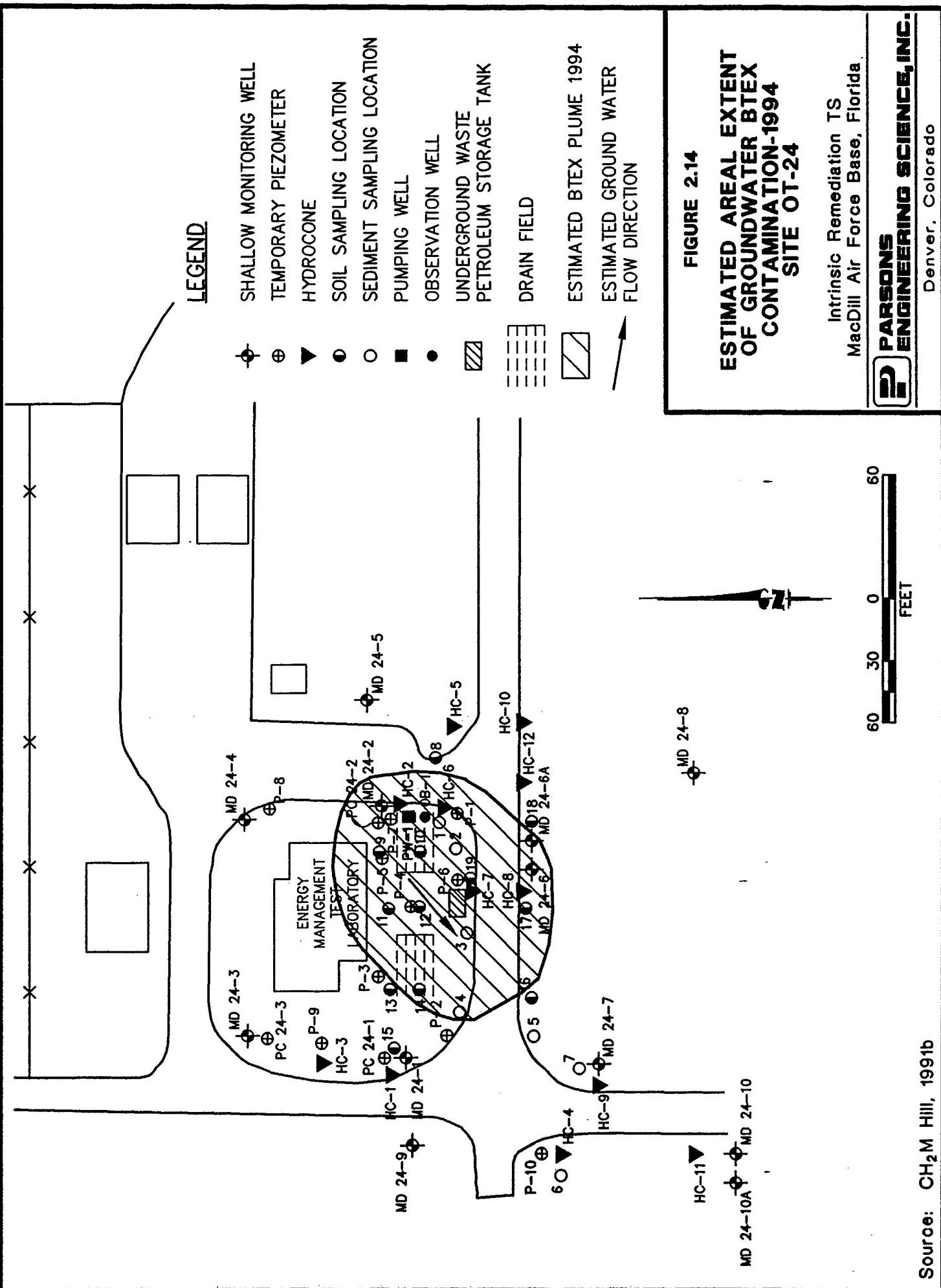
TABLE 2.11
SUMMARY OF HYDROCONE GROUND WATER ANALYTICAL DATA
SITE OT-24
INTRINSIC REMEDIATION TS
MACDILL AFB, FLORIDA

Location	Depth (Feet bgs)	Volatile Organics ($\mu\text{g/L}$) EPA Method 601
HC-1	7	ND ^{a/}
HC-1	18	ND
HC-2	7	Vinyl Chloride - 26.6 1,1-Dichloroethane - 119
HC-2	18	ND
HC-3	10	ND
HC-4	10	1,1-Dichloroethane - 3.5
HC-5	10	ND
HC-6	10	1,1-Dichloroethane - 3.0
HC-7	10	Vinyl Chloride - 59.4 1,1-Dichloroethane - 124
HC-8	10	Vinyl Chloride - 43.3 1,1-Dichloroethane - 178
HC-9	10	ND
HC-10	10	ND
HC-11	10	1,1-Dichloroethane - 1.9
HC-12	10	1,1-Dichloroethane - 1.2
MD24-6	2-12	1,1-Dichloroethane - 1.0
Pumping Well	10-20	Vinyl Chloride - 19-23 1,1-Dichloroethane - 23-26

Source: CH2M Hill, 1991b.

^{a/} ND = No analytes detected.





Source: CH²M Hill, 1991b

M:\45021\DRAWINGS\94DN1500.1\25\95 at 7:50

inside the waste holding tank at Site OT-24 were identified to be 13,800 µg/L in December 1988 (CH2M Hill, 1990 and 1991a).

The presence of free-phase hydrocarbons has been documented at Site OT-24 in wells and piezometers located near the Fuels Management Testing Laboratory building. Free-phase hydrocarbons were measured in pumping well PW-3 (1.93 feet) and in recovery well RW-2 (0.6 foot). Free-phase hydrocarbons were also identified in piezometers P-3, P-4, P-5, P-6, and P-7, all located near the drain fields south of the laboratory building. In the piezometers, a maximum product thickness of 2.62 feet was measured in P-4 in October 1989. Between September 15 and October 2, 1989, all five piezometers showed increases in the thicknesses of free-phase hydrocarbons. This increase in product thickness is most likely associated with the performance of an aquifer pumping test during that time period.

Chlorinated contaminants also have been identified in hydrocone and ground water monitoring well samples collected at Site OT-24. Table 2.11 presents a summary of ground water analytical data for hydrocone samples, and Table 2.12 presents ground water analytical data for samples collected from the 12 monitoring wells. Hydrocone and monitoring well analytical data from ground water samples taken in May 1989 indicated that 1,1-dichloroethane (DCA) contamination extended from the eastern drain field south of the laboratory building, southeastward to monitoring well MD 24-10. Maximum concentrations of 1,1-DCA were found in the vicinity of the eastern drain field in hydrocone punches HC-8 (178 µg/L), HC-7 (124 µg/L), and HC-2 (119 µg/L). A comparative analysis of data from 1989, presented above and monitoring well data collected in 1994, indicated little change in the areal extent and concentration of 1,1-DCA contamination. Vinyl chloride contamination was identified in those hydrocone punches located near the eastern drain field at concentrations ranging from 25 to 45 µg/L. Monitoring wells in the drain field area and to the southeast of the laboratory also showed vinyl chloride contamination of less than 10 µg/L. In addition, trichloroethene (TCE) and dichloroethene (DCE) were identified in monitoring well MD 24-2 in concentrations less than 5 µg/L.

2.1.3.2 Pumphouse 75 (Site 57)

A ground water screening survey was performed using a hydrocone (direct-push) sampling probe to sample water within the surficial aquifer. Figure 1.4 shows the locations of the hydrocone sampling. BTEX constituents were detected in 9 of the 10 hydrocone samples. Table 2.13 presents a summary of ground water analytical data for Pumphouse 75 (Site 57). Highest total BTEX concentrations were found in samples located on the southwest side of the pumphouse near the fuel pipeline, with samples HC09 and HC03 containing 1,014 µg/L and 838 µg/L of total BTEX, respectively.

TABLE 2.13
SUMMARY OF GROUNDWATER ANALYTICAL DATA
PUMPHOUSE 75 (SITE 57)
INTRINSIC REMEDIATION TS
MACDILL AFB, FLORIDA

Parameter	Sampling Location													
	MW01	MW02	MW03	MW04	MW05	HC01	HC02	HC03	HC04	HC05	HC06	HC07	HC08	HC09
Halogenated Volatile Organics $\mu\text{g/L}^{\text{a}}$														
Methylene Chloride	0.8J	0.8J	1.1	-	0.7J	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cis-1,2 dichloroethylene	NA	NA	NA	NA	NA	<5	<5	19	<5	<5	<5	20	<5	<5
1,1,1 trichloroethane	NA	NA	NA	NA	NA	<5	<5	<5	<5	<5	<5	2119	<5	<5
Trichloroethene	NA	NA	NA	NA	NA	1J	<5	15	<5	<5	<5	1J	<5	<5
Tetrachloroethene	NA	NA	NA	NA	NA	3J	<5	10	20	6	<5	<5	2J	6
Aromatic Volatile Organics $\mu\text{g/L}^{\text{a}}$														
Benzene	-	-	-	187	-	<1	<1	55	<1	40	<1	<1	<1	<1
Ethylbenzene	-	-	-	884	-	<1	3	783	<1	37	<1	3	<1	<1
Toluene	NA	NA	NA	NA	NA	2	<1	<1	<1	<1	<1	<1	<1	<1
Total Xylenes	NA	NA	NA	NA	NA	10	9	<1	9	12	<1	3	6	1014
Total BTEX	-	-	-	-	1071	-	12	12	838	9	89	<1	6	6
Total VOCs	-	-	-	-	1071	-	12	12	838	9	89	<1	6	6
PAHs $\mu\text{g/L}$ (8100)														
Naphthalene	-	-	-	615.2	-	NA								
Acenaphthylene	-	-	-	91.5	-	NA								
1-methylnaphthalene	-	-	-	105.8	-	NA								
2-methylnaphthalene	-	-	-	108.6	-	NA								
Total PAHs (excl. naphthalene)	-	-	-	91.5	-	NA								
Total Naphthalenes	-	-	-	-	829.6	-	NA							
TRPH $\mu\text{g/L}$ (418.1)	-	-	-	0.5	6.2	-	NA							
RCRA Metals $\mu\text{g/L}$														
Barium	26.2	11.9	44.5	36.7	21.2	NA								
Chromium	19.1	10.4	5.6	7.5	18.1	NA								
Lead	5.9	-	7.1	3.7	-	NA								

Source: BVWS, In preparation.

^a All MW samples analyzed by Method 8010, all HC samples analyzed by Method 601
^b All MW samples analyzed by Method 8020, all HC samples analyzed by Method 602

- = not detected

NA = not analyzed for
 J = estimated value

BTEX contamination in the ground water was found to extent across approximately 2.5 acres of the site (Figure 2.15) (BVWS, In Preparation).

Ground water samples were collected from the five monitoring wells in January 1994. Laboratory analytical results are presented in Table 2.13 and are shown in Figure 2.15. The highest total BTEX contamination concentrations were found in monitoring well MW04, west of the pumphouse adjacent to the jet fuel pipeline. Total BTEX concentrations of 1,071 µg/L were detected in samples taken from MW04, with 824 µg/L being comprised of ethylbenzene and the remaining concentration comprised of benzene. No other monitoring well sample showed the presence of BTEX constituents. In addition to BTEX compounds, samples from monitoring well MW04 also contained 6,200 µg/L of TRPH, and 829 µg/L of total naphthalene. Monitoring well MW03 showed evidence of contamination, with 500 µg/L of TRPH. No free product measurements were presented by BVWS (BVWS, In Preparation)

2.1.3.3 Site 56

The results of the hydrocone field testing performed in September 1993, at 18 locations at Site 56 (Figure 1.5) indicate that the highest BTEX concentrations in the ground water are found near the remote fuel pad and the fuel lines that connect the USTs to the remote fuel pad. Table 2.14 presents ground water field and analytical data for Site 56 and Figure 2.16 shows the estimated areal extent of ground water BTEX contamination. The hydrocone ground water samples from MD56-HC02 yielded a total BTEX concentration of 21,490 µg/L, the maximum concentration detected in hydrocone samples at Site 56. Total BTEX concentrations of 356 µg/L, 143 µg/L, and 66 µg/L were identified in the area adjacent to the remote fuel pad at hydrocones MD56-HC05, MD56-HC17, and MD56-HC03, respectively. A total BTEX concentration of 68 µg/L was found at MD56-HC07, upgradient of Building 555. The remaining hydrocone samples, excluding MD56-HC09 and MD56-HC16, contained BTEX constituents, but in concentrations less than 50 µg/L.

Ground water samples were garnered from the seven monitoring wells in October and November 1993. Ground water laboratory analytical data indicate that the highest total BTEX contamination in ground water monitoring wells is found near the abandoned remote fuel pad. Results of the laboratory analyses for the ground water samples are presented in Table 2.14 and shown in Figure 2.16. Samples collected from monitoring wells MD56-MW06 and MD56-MW07 contained 5,719 µg/L and 939 µg/L of total BTEX contamination, respectively. No BTEX constituents were identified in the remaining monitoring well ground water samples. Naphthalene concentrations were also elevated in MD56-MW06 and MD56-MW07.

In addition to BTEX contamination, chlorinated solvents were identified in the hydrocone samples. Chlorinated contaminant concentrations were highest in those

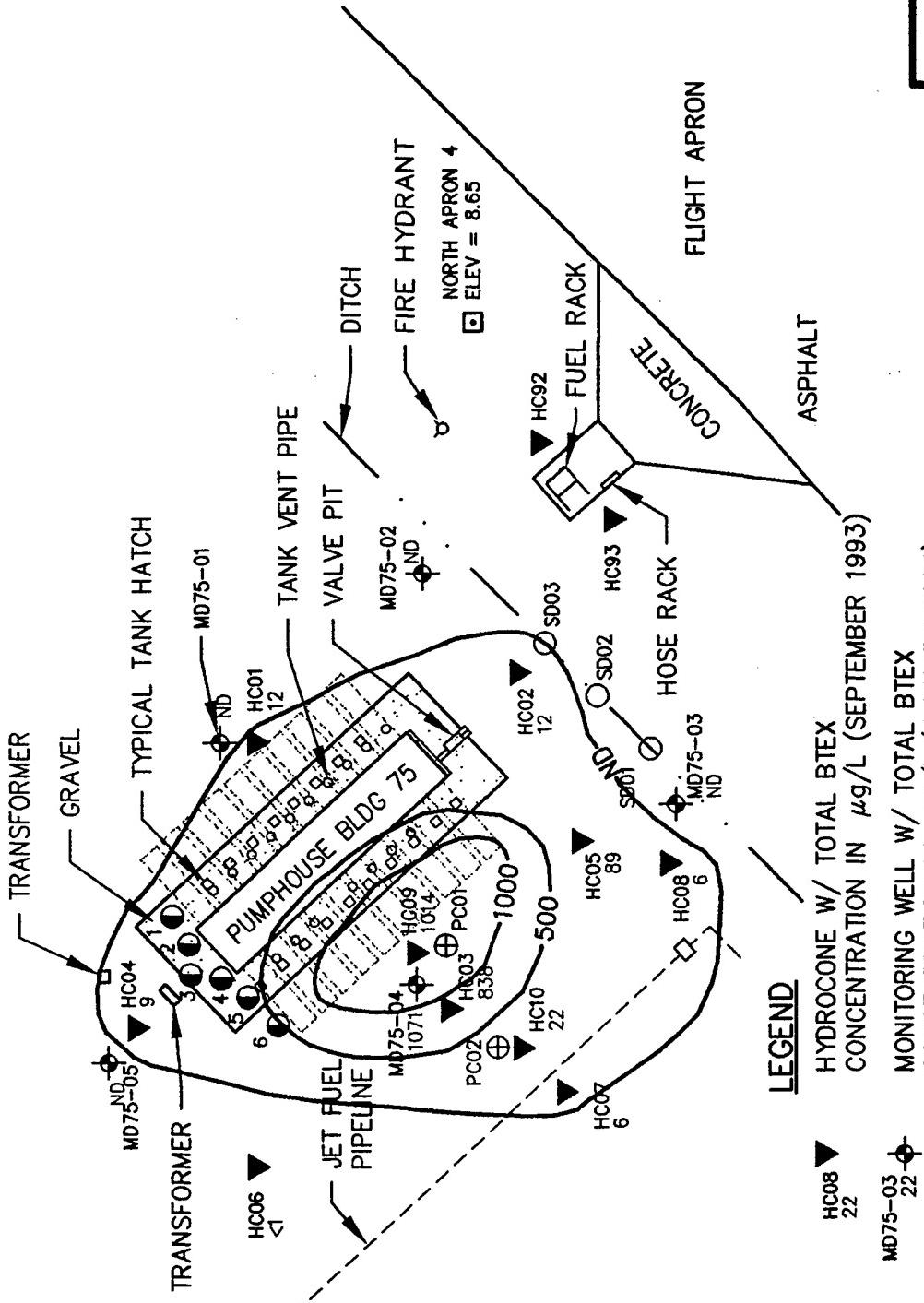


FIGURE 2.15

ESTIMATED AREAL EXTENT
OF GROUND WATER
BTEX CONTAMINATION
PUMPHOUSE 75



Intrinsic Remediation TS
MacDill Air Force Base, Florida
PARSONS
ENGINEERING SCIENCE, INC.
Denver, Colorado

Source: BVWS, In Preparation

TABLE 2.14
SUMMARY OF HYDROCONE FIELD AND GROUND WATER ANALYTICAL DATA
SITE 56
INTRINSIC REMEDIATION TS
MACDILL AFB, FLORIDA

Sample Parameter	Hydrocone Field Sample Locations												Laboratory Sample Locations												
	HC01	HC02	HC03	HC04	HC05	HC06	HC07	HC08	HC09	HC10	HC11	HC12	HC13	HC14	HC15	HC16	HC17	HC18	MW01	MW02	MW03	MW04	MW05	MW06	MW07
Method 602 (ug/L)																									
Benzene	<1	1,390	2	<1	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	24	2	-	-	-	-	-	1,800	207	
Toluene	9	5,310	13	15	114	18	2	<1	<1	<1	<1	<1	<1	<1	<1	57	<1	-	-	-	-	-	2,200	27	
Ethylbenzene	<1	2,590	1	<1	38	1	5	4	<1	13	<1	<1	<1	<1	1	<1	6	2	-	-	-	-	-	249	72
m-Xylene	14	7,600	9	<1	132	7	<1	<1	26	2	<1	<1	<1	<1	<1	38	<1	-	-	-	-	-	-	NA	NA
o-Xylene	<1	4,600	41	<1	72	<1	61	<1	<1	<1	3	6	<1	<1	18	9	-	-	-	-	-	-	-	NA	NA
Total Xylene	14	12,200	50	0	204	7	61	0	0	26	2	0	3	6	0	56	9	-	-	-	-	-	-	1,470	389
Total BTEX	23	21,190	66	15	356	26	68	4	0	39	2	1	3	6	1	0	143	13	-	-	-	-	-	5,719	939
Method 601 (ug/L)																									
Vinyl Chloride	3J	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	0.61	-
Methylene Chloride	<5	1,760	<5	<5	<5	<5	<5	<5	<5	206	<5	77	24	238	96	292	63	<5	-	-	-	-	-	-	-
Trans 1,2 Dichloroethylene	<5	<5	<5	<5	<5	<5	<5	<5	<5	206	<5	77	24	238	96	292	63	<5	-	-	-	-	-	-	-
Cis 1,2 Dichloroethylene	96	<5	<5	<5	166	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-	-
1,1 Dichloroethane	2,500	40,000	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	223	3,049	-	-	-	-	-	-
1,2 Dichloroethane	69,000	1,320,000	36,000	2,000	180,000	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	2,383	1,076	-	-	-	-	-	-
DCE	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-	-	-	-	-	-
TCE	7	1,860	4	3J	36	1J	1J	<5	<5	<5	<5	<5	<5	<5	<5	<5	2J	<5	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	<5	320	<5	<5	<5	<5	<5	<5	<5	1J	<5	<5	<5	1J	<5	<5	<5	1J	NA	NA	NA	NA	NA	NA	NA
Semi Vatiles ug/L (8070)																									
Naphthalene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Total PAH (excl. Naphthalene)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Total Naphthalenes	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
TRPH (418.1) mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
RCRA Metals ug/l																									
Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Chromium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Mercury	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	

Source: BVWS: In preparation

J=Estimated value

- = Not detected

NA=Not available

LEGEND

- MONITORING WELL W/ TOTAL BTEX CONCENTRATION IN mg/L (Nov '93)
- ▼ HYDROCONE LOCATION W/ TOTAL BTEX CONCENTRATION IN mg/L (Sept '93)
- ⊕ PIEZOCONE LOCATION
- ▽ BENCHMARK
- ESTIMATED BTEX PLUME—1993

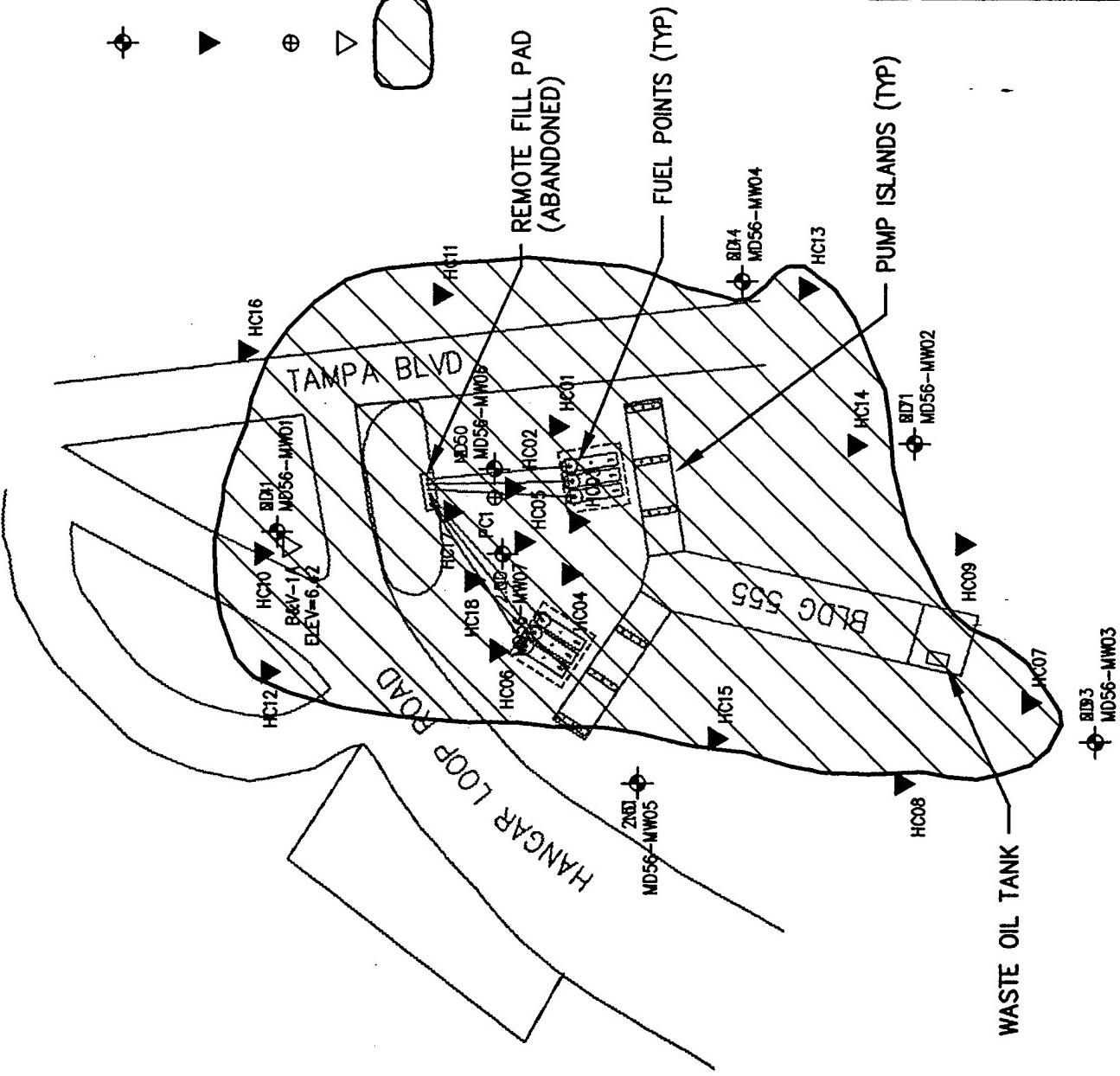


FIGURE 2.16

ESTIMATED AREAL EXTENT OF GROUND WATER BTEX CONTAMINATION, SITE 56



Source: BVWS, In Preparation

M:\45021\DRAWINGS\94DN1527, 1/25/95 at 9:55

Intrinsic Remediation TS
MacDill Air Force Base, Florida

PARSONS
ENGINEERING SCIENCE, INC.

Denver, Colorado

hydrocone tests performed near the remote fuel pad. Field screening results for chlorinated contaminants are summarized in Table 2.14. A concentration of 1,320,000 µg/L of 1,2 DCA was identified in MD56-MW02. The remaining hydrocone samples taken in the remote fuel pad area contained 1,2 dichloroethane concentration of greater than 1,000 µg/L. A concentration of 1,1 DCA of 40,000 µg/L was also identified in the hydrocone samples taken near the remote fuel pad (HC02). High concentrations of Cis 1,2 DCE, TCE, and tetrachloroethene (PCE) were also found near the remote fuel pad. BVWS suggests that the positive identification of chlorinated solvents may be erroneous as field analytical results identifying chlorinated contaminants may represent gasoline constituents with similar gas chromatograph retention times. No chlorinated contamination was found in ground water samples collected from the monitoring wells and laboratory analyzed (BVWS, In Preparation).

2.2 DEVELOPMENT OF CONCEPTUAL MODEL

A conceptual model is a three-dimensional representation of the hydrogeologic system based on available geological, hydrological, climatological, and geochemical data. The purpose of developing a site conceptual model is to provide an understanding of the mechanism for contaminant fate and transport and to identify additional data requirements. The model describes known and suspected sources of contamination, types of contamination, affected media, and contaminant migration pathways. The model provides a foundation for formulating decisions regarding additional data collection activities and potential remedial actions. The conceptual models for Site OT-24, Pumphouse 75, and Site 56 will be used to aid in selecting additional data collection points and to identify appropriate data needs for modeling hydrocarbon degradation using the Bioplume II model.

Successful conceptual model development involves:

- Defining the problem to be solved;
- Integrating available data, including
 - Local geologic and topographic data,
 - Hydraulic data,
 - Site stratigraphic data,
 - Contaminant concentration and distribution data;
- Evaluating contaminant fate and transport characteristics;
- Identifying contaminant migration pathways;
- Identifying potential receptors; and

- Determining additional data requirements.

2.2.1 INTRINSIC REMEDIATION AND THE BIOPLUME II MODEL

After a site has been adequately characterized, fate and transport analyses can be performed to determine the potential for contaminant migration and whether any exposure pathway for human or ecological receptors is complete. The Bioplume II model has proved useful for predicting BTEX plume migration and contaminant attenuation by natural biodegradation. The Bioplume II model (Rifai *et al.*, 1988) can be used to evaluate critical ground water fate and transport processes that may be involved in some of the migration pathways to human and ecological receptors. Quantitative fate and transport analyses can be used to determine what level and extent of remediation is required.

An important consideration in determining whether fuel hydrocarbon contamination presents a substantial threat to human health and the environment and what type of remedial alternative will be most cost effective in eliminating or abating these threats is an accurate estimate of the potential for natural biodegradation of BTEX compounds in the ground water. Over the past two decades, numerous laboratory and field studies have demonstrated that subsurface microorganisms can degrade a variety of hydrocarbons (Lee *et al.*, 1988). This process occurs naturally when sufficient oxygen and nutrients are available in the ground water. The rate of natural biodegradation is generally limited by the lack of oxygen rather than by the lack of nutrients such as nitrogen or phosphorus. The supply of oxygen to unsaturated soil is constantly renewed by the vertical diffusion from the atmosphere. The supply of oxygen to a shallow, fuel-contaminated aquifer is constantly renewed by the influx of oxygenated, upgradient flow and the vertical diffusion of oxygen from the unsaturated soil zone into the ground water (Borden and Bedient, 1986). The rate of natural biodegradation in unsaturated soil and shallow aquifers is largely dependent upon the rate at which oxygen enters the contaminated media.

2.2.2 BIODEGRADATION OF DISSOLVED BTEX CONTAMINATION

The Bioplume II model is a well-documented and widely accepted numerical model available for modeling the fate and transport of fuel hydrocarbons under the influence of advection, dispersion, sorption, and natural aerobic and anaerobic biodegradation. The positive effect of these processes on reducing the actual mass of fuel-related contamination dissolved in ground water has been termed intrinsic remediation. The advantages of intrinsic remediation include: (1) contaminants are transformed to innocuous byproducts (e.g., carbon dioxide and water), not just transferred to another phase or location within the environment; (2) current pump-and-treat technologies are energy intensive and generally not as effective in reducing residual

contamination; (3) the process is nonintrusive and allows continuing use of infrastructure during remediation; (4) current engineered remedial technologies may pose a greater risk to potential receptors than intrinsic remediation because contaminants may be transferred into the atmosphere during remediation activities; and (5) intrinsic remediation is far less costly than conventional, engineered remedial technologies.

To estimate the impact of natural attenuation on the fate and transport of BTEX compounds dissolved in ground water at a site, two important lines of evidence must be demonstrated (Wiedemeier *et al.*, In Preparation). The first is a documented loss of contaminants at the field scale. Dissolved concentrations of biologically-recalcitrant tracers found in most fuel contamination are used in conjunction with aquifer hydrogeologic parameters such as ground water seepage velocity and dilution to demonstrate that a reduction in the total contaminant mass is occurring at the site. The second line of evidence involves the use of chemical analytical data in mass balance calculations to show that areas with BTEX contamination can be correlated to areas with depleted electron acceptor (e.g., oxygen, nitrate, and sulfate) concentrations and increases in metabolic fuel degradation byproduct concentrations (e.g., methane and ferrous iron). With this site-specific information, the Bioplume II computer model can be used to simulate the fate and transport of dissolved BTEX compounds under the influence of the process of natural attenuation.

The Bioplume II model is based upon the US Geological Survey (USGS) two-dimensional (2-D) solute transport model, which has been modified to include a biodegradation component that is activated by a superimposed plume of dissolved oxygen. Bioplume II solves the USGS 2-D solute equation twice, once for hydrocarbon concentrations in the ground water and once for a dissolved oxygen plume. The two plumes are then combined using superimposition at every particle move to simulate biological reactions between fuel products and oxygen. If appropriate, biodegradation of contaminants by anaerobic processes is simulated using a first-order anaerobic decay rate.

2.2.3 Initial Conceptual Models

2.2.3.1 Site OT-24

Site hydrogeologic data were integrated to produce the hydrogeologic cross sections of Site OT-24 (CH2M Hill, 1990 and 1991a). Cross-sections A-A' (Figure 2.3) and B-B' (Figure 2.4) show the dominant hydrostratigraphic units present at Site OT-24 and the water table elevation. Figure 2.5 is a ground water surface map using water table elevation data (CH2M Hill, 1991a).

In the vicinity of the site, ground water exists under unconfined conditions in well-sorted marine sands and silty sands. The saturated thickness of the aquifer averages approximately 20 feet, but increases to over 50 feet in some areas of the site. Based on

available data, Parsons ES will model the site as an unconfined, well-sorted, fine- to medium-grained sand aquifer. Ground water is believed to flow southwest at the site. This conceptual model will be modified as necessary as additional site hydrogeologic data become available.

Free product is present at Site OT-24. Therefore, it will be necessary to use the fuel/water partitioning model of Bruce *et al.* (1991) or Cline *et al.* (1991) to provide a conservative source term to model the partitioning of BTEX compounds from the free-product phase into the ground water. In order to use this model, samples of free product will be collected and analyzed for mass fraction of BTEX compounds.

2.2.3.2 Pumphouse 75 (Site 57)

Little detailed hydrogeologic data are available to define subsurface conditions at Pumphouse 75. It is assumed that conditions at Pumphouse 75 are similar to those found at Site OT-24 (Section 2.1.2.2.1). The saturated thickness of the aquifer was determined to be approximately 20 feet at the site. Based on available data, Parsons ES will model the site as an unconfined, well-sorted, fine- to medium-grained sand aquifer. Local ground water flow is to the southeast. Modifications to the conceptual model will be performed as additional site hydrogeologic data become available.

No free product has been identified at Pumphouse 75. If free product is discovered, it may be necessary to use the fuel/water partitioning model of Bruce *et al.* (1991) or Cline *et al.* (1991) to provide a conservative source term to model the partitioning of BTEX compounds from the free-product phase into the ground water. In order to use this model, samples of free product, if present, will be collected and analyzed for mass fraction of BTEX compounds.

2.2.3.3 Site 56

As limited hydrogeologic data are available to characterize the subsurface at Site 56, it is assumed that subsurface conditions at Site 56 are similar to those found at Site OT-24 (See Section 2.1.2.2.1). The saturated thickness of the aquifer at Site 56 is approximately 17 feet. Parsons ES will model the site as an unconfined, well-sorted, fine- to medium-grained sand aquifer, based on existing data. Local ground water flow is to the north. Modifications to the conceptual site model will be performed as additional site hydrogeological data become available.

No free product was identified in available data for Site 56, but contaminant concentrations recorded in 1993 indicate that free product may be present. If free product is discovered, it may be necessary to use the fuel/water partitioning model of Bruce *et al.* (1991) or Cline *et al.* (1991) to provide a conservative source term to model the

partitioning of BTEX compounds from the free-product phase into the ground water. In order to use this model, samples of free product, if present, will be collected and analyzed for mass fraction of BTEX compounds.

2.2.4 Potential Pathways and Receptors

2.2.4.1 Site OT-24

Potential preferential contaminant migration pathways such as drainage canals, ground water discharge points, and subsurface utility corridors (artificial conduits) will be identified during the field work phase of this project. The primary potential migration paths for hydrocarbon contaminants at the site are from the drain fields, the oil/water separator, and the waste storage tank to the ground water and from the ground water to potential receptors via consumption or other use. Shallow ground water beneath

Site OT-24 flows to the southwest toward a drainage canal that flows into Tampa Bay. It is unlikely that detectable concentrations of contaminants will reach Tampa Bay because of the processes of dilution, dispersion, and degradation. The drainage ditch directly south of the Energy Management Test Laboratory, however, is considered a likely discharge area for contaminants due to its proximity to the site. Other potential completed exposure pathways are the seeps found in the road cut to the south of the laboratory. If contaminated ground water is discharged into Tampa Bay, the drainage canal, or the road cut, a completed pathway to human and ecological receptors may exist. Ground water contamination is not known to have migrated beyond the boundaries of the Base. Exposure to contaminated ground water from the alluvial aquifer may be a completed pathway to human receptors because the alluvial aquifer may be hydraulically connected to deeper limestone aquifers that are used as the primary drinking water source in the Tampa area. Primary potable water supplies for the Base are obtained from the City of Tampa municipal supply.

2.2.4.2 Pumphouse 75 (Site 57)

Potential preferential contaminant migration pathways at Pumphouse 75 include the engineered soils beneath the tarmac of the taxiway, the drainage canals, ground water discharge points, the fuel transfer pipeline, and other subsurface utility corridors (artificial conduits). The migration paths will be identified during the field work phase of this project. The primary potential migration paths for hydrocarbon contaminants at the site are from the USTs and the fuel pipeline to the ground water and from the ground water to potential receptors via consumption or other use. Shallow ground water beneath Pumphouse 75 flows to the southeast toward a drainage swale. It is unlikely that detectable concentrations of contaminants will reach Tampa Bay because of the processes of dilution, dispersion, and degradation, but contamination of the surface water drainage features in the area are a possibility. If contaminated ground water is discharged into

surface drainage canals, a completed pathway to human and ecological receptors may exist. Exposure to contaminated ground water from the alluvial aquifer may be a completed pathway to human receptors because the alluvial aquifer may be hydraulically connected to deeper limestone aquifers that are used as the primary drinking water source in the Tampa area.

2.2.4.3 Site 56

Potential preferential migration pathways such as drainage canals, ground water discharge points, and subsurface utility corridors (artificial conduits) will be identified during the field work phase of this project. The primary potential migration paths for hydrocarbon contaminants at the site are from the USTs along the fuel pipeline to the abandoned remote fuel pad. Shallow ground water beneath Site 56 flows to the north toward a drainage ditch that flows into Tampa Bay. It is unlikely that detectable concentrations of contaminants will reach Tampa Bay because of the processes of dilution, dispersion, and degradation. The drainage ditch to the north is considered a likely discharge area for contamination originating at Site 56. If contaminated ground water is discharged into Tampa Bay or the drainage ditch, a completed pathway to human and ecological receptors may exist. Ground water contamination is not known to have migrated beyond the boundaries of the Base. Exposure to contaminated ground water from the alluvial aquifer may be a completed pathway to human receptors because the alluvial aquifer may be hydraulically connected to deeper limestone aquifers that are used as the primary drinking water source in the Tampa area. Primary potable water supplies for the Base are obtained from the City of Tampa municipal supply.

SECTION 3

COLLECTION OF ADDITIONAL DATA

To complete the TS and to demonstrate that intrinsic remediation of fuel-related contaminants is occurring, additional site-specific hydrogeologic data will be collected. The physical and chemical hydrogeologic parameters listed below will be determined during the field work phase of the TS.

Physical hydrogeologic characteristics to be determined include:

- Depth from measurement datum to the ground water surface in existing monitoring wells;
- Locations of potential ground water recharge and discharge areas;
- Locations of downgradient wells and their uses;
- Hydraulic conductivity through slug tests, as required;
- Estimate of dispersivity, where possible;
- Stratigraphic analysis of subsurface media;
- Temperature; and
- Determination of extent and thickness of free- and residual-phase product.

Chemical hydrogeologic characteristics to be determined include:

- Dissolved oxygen concentration;
- Specific conductance;
- pH;
- Chemical analysis of free product (if present) to determine mass fraction of BTEX; and

- Additional chemical analysis of ground water and soil for the parameters listed in Table 3.1.

To obtain these data, soil, ground water, surface water, sediment, and free product (if present) samples will be collected and analyzed. The following sections describe the procedures that will be followed when collecting additional site-specific data. Drilling, soil sampling, and well point installation will be accomplished using the Geoprobe® system, which is described in Sections 3.1 and 3.2. Procedures to be used to collect soil core samples are described in Section 3.1. Procedures to be used for the installation of new monitoring points are described in Section 3.2. Procedures to be used to sample existing ground water monitoring wells and newly installed ground water monitoring points are described in Section 3.3. Procedures used to measure aquifer parameters (e.g. hydraulic conductivity) are described in Section 3.4.

3.1 SOIL SAMPLING

The following describe sample collection techniques, sampling locations at the respective sites, equipment decontamination procedures, site restoration, and management of investigation-derived waste materials.

3.1.1 Sample Collection Using the Geoprobe® System

The Geoprobe® system is a hydraulically powered percussion/probing machine used to advance sampling tools through unconsolidated soils. This system provides for the rapid collection of soil, soil gas, and ground water samples at shallow depths while minimizing the generation of investigation-derived waste materials. Figure 3.1 is a diagram of the Geoprobe® system. The following sections describe soil sample collection methods, well point installation methods, and decontamination methods using the Geoprobe® system.

Soil samples will be collected using a probe-drive sampler. The probe-drive sampler serves as both the driving point and the sample collection device and is attached to the leading end of the probe rods. To collect a soil sample, the sampler is pushed or driven to the desired sampling depth, the drive point is retracted, which opens the sampling barrel, and the sampler is subsequently pushed into the undisturbed soils. The soil cores are retained within brass, stainless steel, or clear acetate liners inside the sampling barrel. The probe rods are then retracted, bringing the sampling device to the surface. The soil sample can then be extruded from the liners for logging or the liners can be capped and undisturbed samples submitted to the analytical laboratory for testing.

If the probe-drive sampling techniques described above are inappropriate, inadequate, or unable to efficiently provide sufficient soil samples for the characterization

TABLE 3.1
ANALYTICAL PROTOCOL FOR
GROUND WATER AND SOIL SAMPLES

MACDILL AIR FORCE BASE, FLORIDA

MATRIX	METHOD	FIELD (F) OR ANALYTICAL LABORATORY (L)
WATER		
Total Iron	Colorimetric, HACH Method 8008 (or similar)	F
Ferrous Iron (Fe+2)	Colorimetric, HACH Method 8146 (or similar)	F
Ferric Iron (Fe+3)	Difference between total and ferrous iron	F
Manganese	Colorimetric, HACH Method 8034 (or similar)	F
Sulfide	Colorimetric, HACH Method 8131 (or similar)	F
Sulfate	Colorimetric, HACH Method 8051 (or similar)	F
Nitrate	Titrimetric, HACH Method 8039 (or similar)	F
Nitrite	Titrimetric, HACH Method 8507 (or similar)	F
Redox Potential	A2580B, direct reading meter	F
Oxygen	Direct reading meter	F
pH	E150.1/SW9040, direct reading meter	F
Conductivity	E120.1/SW9050, direct reading meter	F
Temperature	E170.1	F
Alkalinity (Carbonate [CO ₃ -2] and Bicarbonate [HCO ₃ -1])	Titrimetric, HACH Method 8221 (or similar)	F
Carbon Dioxide	CHEMetrics Method 4500	F
Nitrite	E300 or SW9056	L
Chloride	E300 or SW9056	L
Sulfate	E300 or SW9056	L
Alkalinity	E150.1	L
Methane	RSKSOP175	L
Total Organic Carbon	A5310C	L
Aromatic Hydrocarbons (Including Trimethylbenzene and Tetramethylbenzene)	SW8020 (RSKSOP-133)	L
Total Hydrocarbons	SW8015, modified	L
Volatile Organics	GS/MS method, SW8240	L
Free Product	GS/MSD fuel identification	L
Ammonia--Diss. Gas in Water	RSKSOP	L
SOIL		
Total Organic Carbon	SW9060	L
Moisture	ASTM D-2216	L
Aromatic Hydrocarbons	SW8020	L
Total Hydrocarbons	SW8015, modified	L

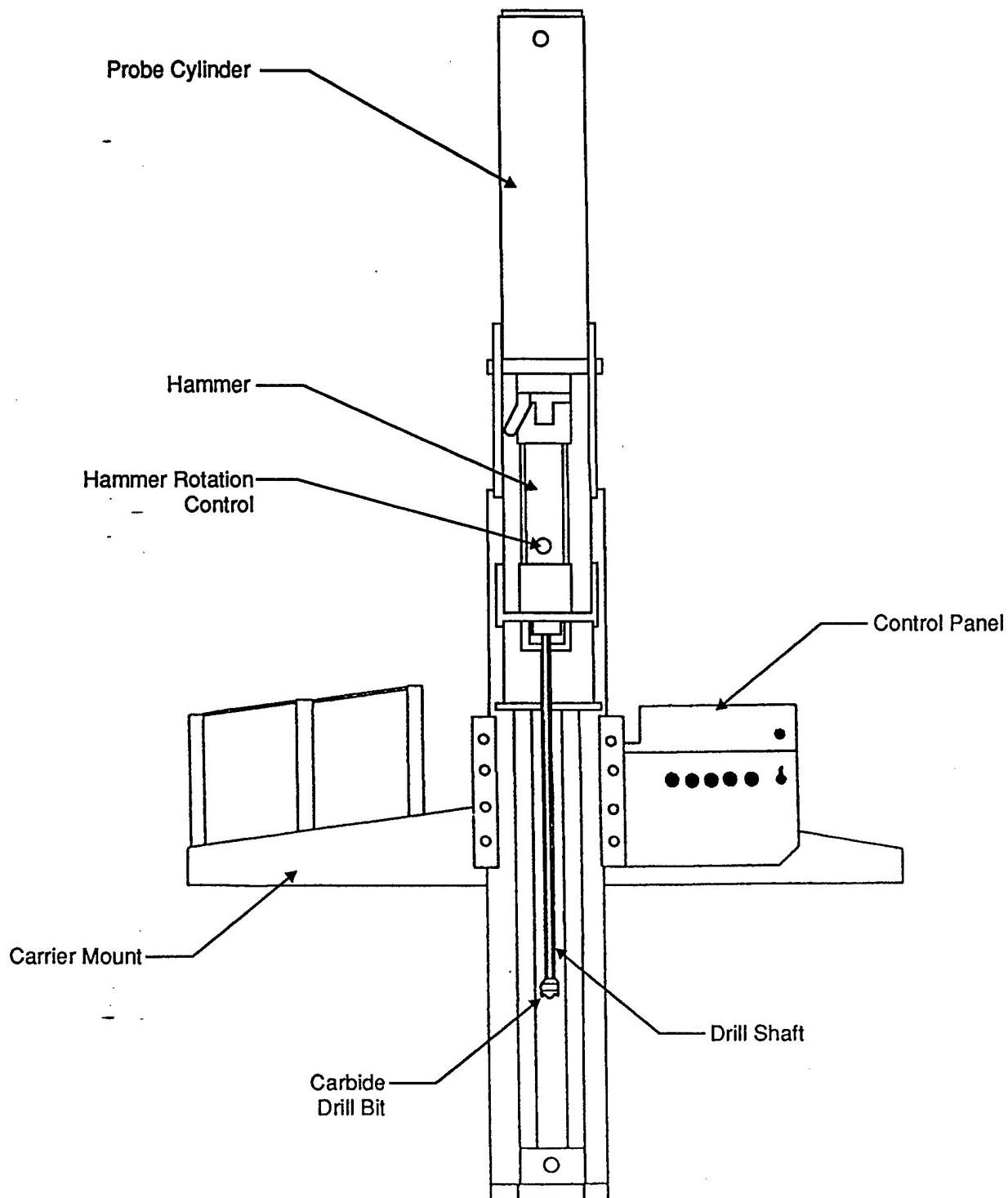


Figure 3.1

**CROSS SECTION OF
GEOPROBE**

Intrinsic Remediation TS
MacDill Air Force Base, Florida

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

of the site, continuous soil samples will be obtained from conventional core boreholes using a hand auger or similar method judged acceptable by the Parsons ES field scientist. Procedures will be modified, if necessary, to ensure good sample recovery.

The Parsons ES field scientist will be responsible for observing all field investigation activities, maintaining a detailed descriptive log of all subsurface materials recovered during soil coring, photographing representative samples, and properly labeling and storing samples. An example of the proposed geologic boring log form is presented in Figure 3.2. The descriptive log will contain:

- Sample interval (top and bottom depth);
- Sample recovery;
- Presence or absence of contamination;
- Lithologic description, including relative density, color, major textural constituents, minor constituents, porosity, relative moisture content, plasticity of fines, cohesiveness, grain size, structure or stratification, relative permeability, and any other significant observations; and
- Depths of lithologic contacts and/or significant textural changes measured and recorded to the nearest 0.1 foot.

Base personnel will be responsible for identifying the location of all utility lines, USTs, fuel lines, or any other underground infrastructure prior to any sampling activities. All necessary digging permits will be obtained by Base personnel prior to mobilizing to the field. Base personnel will also be responsible for acquiring drilling and monitoring point installation permits for the proposed locations. Parsons ES will be responsible for providing trained operators for the Geoprobe®.

3.1.2 Soil Sample Locations and Required Analyses

The following sections identify the proposed locations for soil sampling at the demonstration sites at MacDill AFB. Table 3.1 presents an analytical protocol for ground water and soil samples, and Appendix A contains detailed information on the analyses and methods used during this sampling effort.

3.1.2.1 Site OT-24

Soil samples will be collected at all Geoprobe® and monitoring point installation locations. Figure 3.3 identifies the proposed locations of soil sample collection at Site OT-24. A minimum of two samples will be taken in each hole punched: one sample will be taken at the water table and one will be taken at the depth of maximum BTEX contamination as determined by soil headspace screening. Soil samples will also be

GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: _____ CONTRACTOR: _____ DATE SPUD: _____
 CLIENT: AFCEE RIG TYPE: _____ DATE CMPL.: _____
 JOB NO.: 722450.21 DRLG METHOD: _____ ELEVATION: _____
 LOCATION: MACDILL AFB BORING DIA.: _____ TEMP: _____
 GEOLOGIST: _____ DRLG FLUID: _____ WEATHER: _____
 COMMENTS: _____

Elev (ft)	Depth (ft)	Pro- file	US CS	Geologic Description	Sample	Sample	Penet	PID(ppm)	WkSPC	TOTAL	TPH (ppm)
					No.	Depth (ft)	Type				
- 1 -											
5											
10											
15											
20											
25											
30											
35											

NOTES

bgs – Below Ground Surface
 GS – Ground Surface
 TOC – Top of Casing
 NS – Not Sampled
 SAA – Same As Above

SAMPLE TYPE

D – DRIVE
 C – CORE
 G – GRAB

 Water level drilled

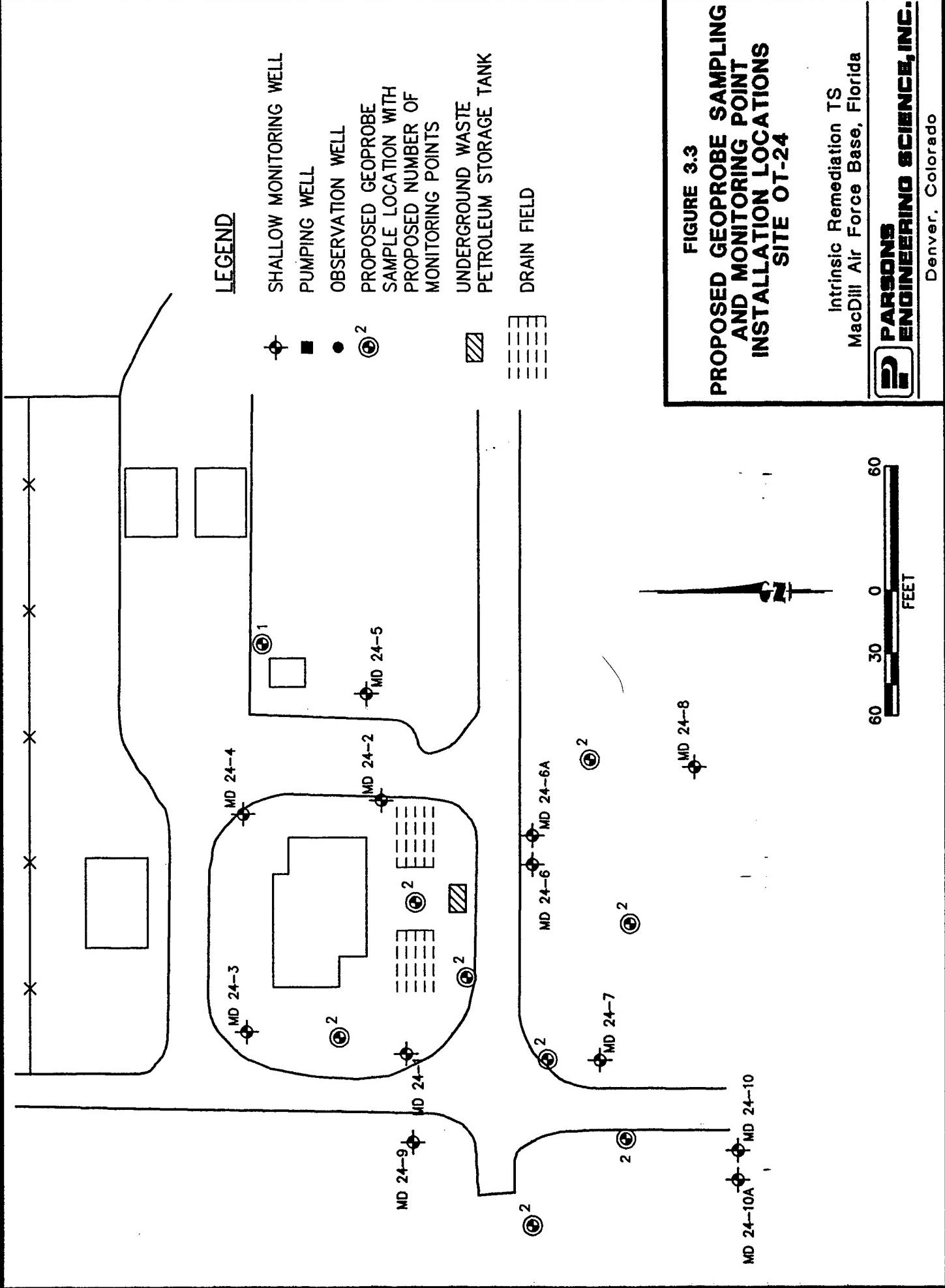
FIGURE 3.2 GEOLOGIC BORING LOG

Intrinsic Remediation TS
 MacDill Air Force Base, Florida



**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado



collected in or near the drainage ditch and swale to the southwest of the laboratory building at the depth of ground water. In addition, soil samples will be collected from the road cut if visible or other evidence of contamination is present. Additional samples and sampling intervals will be collected at the discretion of the Parsons ES scientist.

A portion of the sample will be sent to the laboratory for analytical analysis while another portion of the sample will be utilized to determine soil headspace. Each laboratory soil sample will be placed in an analyte-appropriate sample container and shipped to the analytical laboratory for analysis of total hydrocarbons, aromatic hydrocarbons, and moisture content using the procedures presented in Table 3.1. In addition, two samples will be analyzed for total organic carbon (TOC) from a location upgradient of the contaminant source. Each headspace screening sample will be placed in a sealed plastic bag or mason jar and allowed to sit for at least 5 minutes. Soil headspace will then be determined using an organic vapor meter (OVM) and the results will be recorded in the field records by the Parsons ES field scientist.

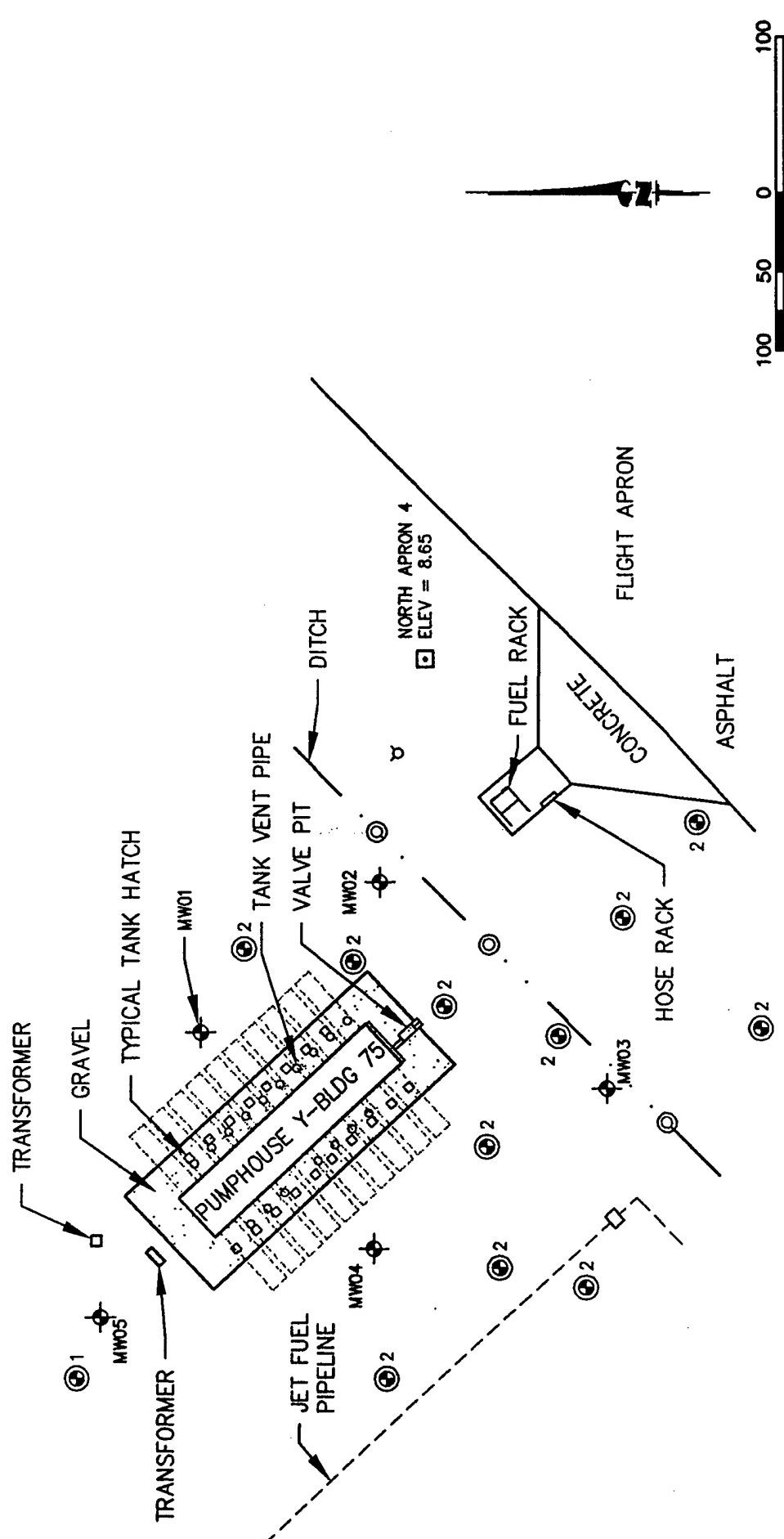
3.1.2.2 Pumphouse 75 (Site 57)

Soil samples will be collected at all Geoprobe® and monitoring point installation locations. Figure 3.4 identifies the proposed locations of soil samples at Pumphouse 75. A minimum of two samples will be taken in each hole punched: one sample will be taken at the water table and one will be taken at the depth of maximum BTEX contamination as determined by soil headspace screening. Soil samples will also be collected in or near the drainage ditches and swales located downgradient of the pumphouse building at the depth of ground water. Additional samples and sample intervals will be collected at the discretion of the Parsons ES field scientist

A portion of the sample will be sent to the laboratory for analytical analysis while another portion of the sample will be utilized to determine soil headspace. Each laboratory soil sample will be placed in an analyte-appropriate sample container and shipped to the analytical laboratory for analysis of total hydrocarbons, aromatic hydrocarbons, and moisture content using the procedures presented in Table 3.1. In addition, two samples will be analyzed for TOC from a location upgradient of the contaminant source. Each headspace screening sample will be placed in a sealed plastic bag or mason jar and allowed to sit for at least 5 minutes. Soil headspace will then be determined using an OVM and the results will be recorded in the Parsons ES field scientist's field records.

3.1.2.3 Site 56

Soil samples will be collected at all Geoprobe® and monitoring point installation locations. Figure 3.5 identifies the proposed locations of soil samples at Site 56. A



- MD75-03 MONITORING WELL
 (○) PROPOSED SURFACE WATER AND
 SEDIMENT SAMPLE LOCATION
 (□) BENCHMARK
 (◎) PROPOSED GEOPROBE SAMPLING
 LOCATION W/ NUMBER OF PROPOSED
 MONITORING POINTS

100
50
0
100
FEET

FIGURE 3.4

**PROPOSED GEOPROBE SAMPLING
 AND MONITORING POINT
 INSTALLATION LOCATIONS
 PUMPHOUSE 75**

Intrinsic Remediation TS
 MacDill Air Force Base, Florida

**PARSONS
 ENGINEERING SCIENCE, INC.**

Denver, Colorado

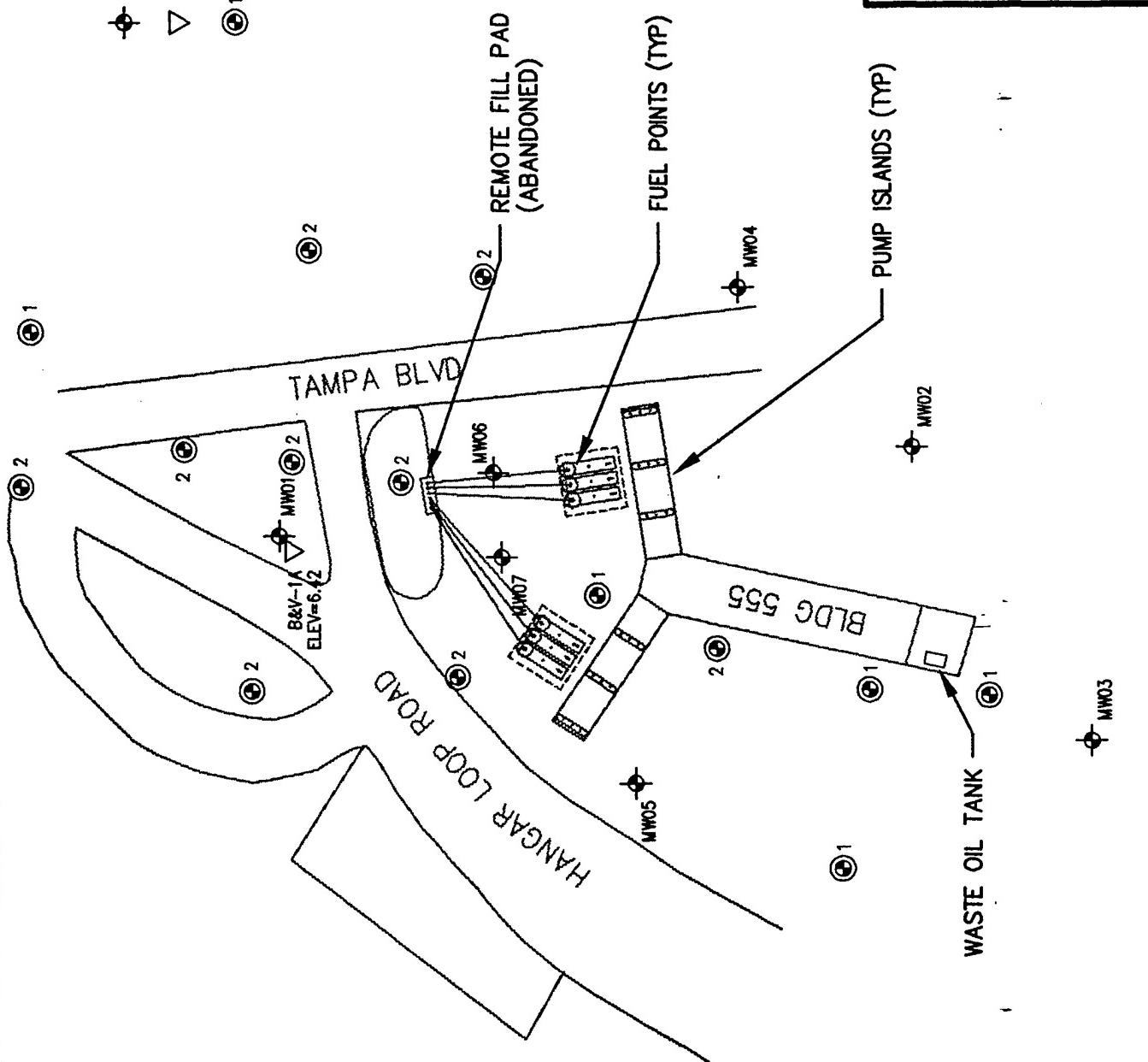


FIGURE 3.5
**PROPOSED GEOPROBE SAMPLING
 AND MONITORING POINT
 INSTALLATION LOCATIONS
 SITE 56**

Intrinsic Remediation TS MacDill Air Force Base, Florida

Denver, Colorado

**PARSONS
ENGINEERING SCIENCE, INC.**

minimum of two samples will be taken in each hole punched: one sample will be taken at the water table and one will be taken at the depth of maximum BTEX contamination as determined by soil headspace screening. Three soil samples will also be collected in or near the drainage ditch to the north of the gasoline station at the depth of the water table. Additional samples and sample intervals will be collected at the discretion of the Parsons ES field scientist.

A portion of the sample will be sent to the laboratory for analytical analysis while another portion of the sample will be utilized to determine soil headspace. Each laboratory soil sample will be placed in an analyte-appropriate sample container and shipped to the analytical laboratory for analysis of total hydrocarbons, aromatic hydrocarbons, and moisture content using the procedures presented in Table 3.1. In addition, two samples will be analyzed for TOC from a location upgradient of the contaminant source. Each headspace screening sample will be placed in a sealed plastic bag or mason jar and allowed to sit for at least 5 minutes. Soil headspace will then be determined using an OVM and the results will be recorded in the field records by the Parsons ES field scientist.

3.1.3 Datum Survey

The horizontal location of all soil sampling locations relative to established Base coordinates will be measured by a surveyor. Horizontal coordinates will be measured to the nearest 0.1 foot. The elevation of the ground surface will also be measured to the nearest 0.1 foot relative to USGS MSL data.

3.1.4 Site Restoration

After sampling is complete, each sampling location will be restored as closely to its original condition as possible. Holes created by the Geoprobe® in sandy soils similar to those found at the Base tend to cave in soon after extraction of the drive sampler. However, any test holes remaining open after extraction of the penetrometer rod will be sealed with bentonite chips, pellets, or grout to eliminate any creation or enhancement of contaminant migration pathways to the ground water. Soil sampling using the Geoprobe® creates low volumes of soil waste. Soil not used for sampling will be placed in 55-gallon drums provided by the Base and disposed of by Base personnel. Alternate methods of soil waste disposal will be considered by the Parsons ES field scientist as recommended by Base personnel.

3.1.5 Equipment Decontamination Procedures

Prior to arriving at the site, and between each sampling location, probe rods, tips, sleeves, pushrods, samplers, tools, and other downhole equipment will be decontaminated using a high-pressure, steam/hot water wash. Only potable water will be used for

decontamination. All rinseate will be collected in 55-gallon drums provided by the Base and later transported and disposed of by Base personnel.

Between each soil sample, the sampling barrel will be disassembled and decontaminated with Alconox® and potable water. The barrel will then be rinsed with deionized water and reassembled with new liners. Between uses, the sampling barrel will be wrapped in clean plastic or foil to prevent contamination.

Rinseate will be collected in 55-gallon drums provided by the Base. Filled 55-gallon drums will be stored at the Base, and Base personnel will arrange for final disposal of the drums and their contents. Base personnel are responsible for sampling the contents of the drums to identify any hazardous constituents before the drums are transported to an appropriate disposal facility.

Potable water to be used during equipment cleaning, decontamination, or grouting will be obtained from one of the Base water supplies. Water use approval will be verified by contacting the appropriate facility personnel. The field scientist will make the final determination as to the suitability of site water for these activities. Precautions will be taken to minimize any impact to the surrounding area that might result from decontamination operations.

3.2 SURFACE WATER AND SEDIMENT SAMPLING

This section describes the scope of work required for collection of surface water and sediment samples at locations where a completed contaminant pathway is possible. These locations include drainage ditches, swales, and other areas where contaminated ground water may contact the ground surface. In order to maintain a high degree of QC during this sampling event, the procedures described in the following sections will be followed.

Sampling will be conducted by qualified scientists and technicians trained in the conduct of surface water and sediment sampling, records documentation, and chain-of-custody procedures. In addition, sampling personnel will have thoroughly reviewed this work plan prior to sample acquisition and will have a copy of the work plan available onsite for reference.

The following summarizes the activities that will occur during surface water and sediment sampling:

- Assembly and preparation of equipment and supplies;
- Surface water sampling, including
 - Visual inspection of sample water,

- Sample collection;
- Sample preservation and shipment, including
 - Sample preparation,
 - Onsite measurement of physical parameters, and
 - Sample labeling;
- Completion of sampling records; and
- Sample disposition.

Detailed surface water and sediment sampling and sample handling procedures are presented in following sections.

3.2.1 Surface Water and Sediment Sampling Strategy and Required Analysis

Surface water samples will be collected from shallow surface water bodies that are located downgradient of the source areas and are a potential completed contamination pathway. Sediment samples will be collected from surface water bodies that contain high volumes of water or low areas that show evidence of standing water. Sediment samples will only be collected if soil sampling with the Geoprobe® in the areas described below and in Sections 3.1.2.1 through 3.1.2.3 proves to be ineffective.

3.2.1.1 Site OT-24

At Site OT-24, surface water and sediment samples will be collected from the drainage ditch and swale south of the laboratory building (Figure 3.3). Sediment samples will be collected in areas where no surface water or large volumes of water are present. Sediment or surface soil samples will also be collected in areas of potential ground water seepage such as the road cut south of the laboratory building. The location of surface water and sediment sampling and number of samples collected will be determined by the Parsons ES field scientist depending upon site conditions. Each surface water and sediment sample will be analyzed for aromatic hydrocarbons.

3.2.1.2 Pumphouse 75

Surface water and sediment samples will be collected from the drainage ditch south of the pumphouse building (Figure 3.4). Sediment samples will be collected in areas where no surface water or large volumes of water are present. The location of surface water and sediment sampling and number of samples collected will be determined by the Parsons ES field scientist depending upon site conditions. Each surface water and sediment sample will be analyzed for aromatic hydrocarbons.

3.2.2.2 Equipment Calibration

As required, field analytical equipment will be calibrated according to the manufacturers' specifications prior to field use. This applies to equipment used for onsite measurements of oxygen, temperature, conductivity, and pH.

3.2.3 Sampling Procedures

To prevent sample contamination, the hand auger, shovel, and/or drive sampler will be cleaned properly before use and between sampling locations as described in Section 3.2.2.1. In addition to the use of properly cleaned equipment, a clean pair of new, disposable nitrile or latex gloves will be worn each time a different location is sampled. The following paragraphs present the procedures to be followed for surface water and sediment sample collection. These activities will be performed in the order presented below. Exceptions to this procedure will be noted in the sampler's field notebook.

3.2.3.1 Preparation of Location

Prior to starting the sampling procedure, the area around the sample location will be cleared of foreign materials, such as brush, rocks, and debris. These procedures will prevent sampling equipment from inadvertently contacting debris around the sample location.

3.2.3.2 Sample Extraction

For surface water samples, a sample container or dedicated, Teflon[®]-lined, high-density polyethylene (HDPE) tubing and a peristaltic pump will be used to extract surface water samples from surface water bodies. Sample containers will be filled directly from the surface of the water body. If this method proves unacceptable, a peristaltic pump and HDPE tubing will be utilized. The end of the tubing will be placed on the surface of the water and the sample will be transferred directly into the appropriate sample container.

At locations where sediment samples will be obtained, a hand auger or shovel will be utilized to collect the sample if no surface water is present. Samples will be collected from the boring device and transferred directly into an appropriate sample container.

If surface water is present, sediment samples will be collected using a drive sampler to protect the sample from contamination with surface water. Samples will be collected in protective plastic sleeve and transferred directly into an appropriate sample container.

3.3 MONITORING POINT INSTALLATION

To provide additional information on contaminant distribution and concentrations and ground water elevations at the sites, monitoring points will be installed. While the Florida Administrative Code requires that permanent monitoring wells follow specific construction guidelines, it is possible to utilize wells constructed in the manner of monitoring points as permanent monitoring points. Monitoring points (as outlined in Section 3.2.2) will be installed in all the locations and developed as described in Sections 3.2.4 and 3.2.5. Sampling of these points will follow procedures outlined in Section 3.3.

The following sections describe the proposed monitoring point locations and completion intervals, monitoring point installation, monitoring point development, and equipment decontamination procedures.

3.3.1 Monitoring Point Installation Locations and Completion Intervals

The following sections describe the locations of monitoring well points and screen intervals at Site OT-24, Pumphouse 75, and Site 56. Existing data for each site were utilized to determine the proposed installation locations for the new monitoring points. Shallow monitoring points will be placed across the water table. Deep monitoring points will be placed at least 5 feet below the bottom of the shallow monitoring point screen. The location of proposed monitoring points and the completion intervals presented in the following sections are tentative and may be altered at the discretion of the Parsons ES field scientist.

3.3.1.1 Site OT-24

As many as 18 new monitoring points will be installed at Site OT-24. The proposed installation locations of the new monitoring points are shown on Figure 3.3. Proposed monitoring point installation locations are positioned to characterize the projected centerline of the contaminant plume, the lateral edges of the contaminant plume, and an upgradient site to obtain an uncontaminated sample. The contaminant plume is thought to originate near the eastern drain field and to extend to the southwest. Eight of the proposed locations will have two monitoring points installed at two depths, a shallow screened interval monitoring point and a deep screened monitoring point. The depth of the shallow monitoring point will be between 2.5 and 10 feet bgs, depending upon the elevation of ground water at each location. The top of the screened interval of the deep monitoring points will be placed 5 to 15 feet below the bottom of the screened interval of the shallow monitoring point. A single monitoring point with a shallow screened interval is proposed at an upgradient site, in the grassy area northeast of the laboratory building. Each monitoring point will have a screened interval of 1 meter. The

depth of monitoring points will be determined by the Parsons ES field scientist depending upon site conditions.

3.3.1.2 Site 57 (Pumphouse 75)

Up to 25 new monitoring points will be installed at Pumphouse 75. Figure 3.4 presents the proposed installation locations of the new monitoring points. Proposed monitoring point installation locations are positioned to characterize the projected centerline of the contaminant plume, beginning near monitoring well MD75-04 and extending to the southeast. Monitoring points are also proposed to determine the lateral edges of the contaminant plume, the contamination associated with the jet fuel pipeline, and an upgradient site to obtain an uncontaminated sample. Two pairs of monitoring points are positioned to identify contamination originating from the USTs on the northwest side of Building 75. Ten of the proposed locations will have two monitoring points installed at two depths, a shallow screened interval monitoring point and a deep screened monitoring point. The depth of the shallow monitoring point will be placed between 4 to 7 feet bgs, depending upon the elevation of ground water at each location. The top of the screened interval of the deep monitoring points will be placed 5 to 15 feet below the bottom of the screened interval of the shallow monitoring point. The depth of the deep monitoring point will be determined by the Parsons ES field scientist depending upon site conditions. A single monitoring point with a shallow screened interval is proposed upgradient of the pumphouse building. Each monitoring point will have a screened interval of 1 meter.

3.3.1.3 Site 56

As many as 23 new monitoring points will be installed at Site 56. Figure 3.5 presents the proposed installation locations of the new monitoring points. Proposed monitoring point installation locations are positioned to characterize the projected centerline of the contaminant plume, beginning near the abandoned remote fill pad and extending to the north. Monitoring points are also proposed to determine the lateral edges of the contaminant plume and an upgradient site to obtain an uncontaminated sample. One pair of monitoring points and three single monitoring points are positioned to identify contamination associated with the waste oil tank located at the southwest corner of Building 555. A single monitoring point was placed to identify contamination between the USTs. Nine of the proposed locations will have two monitoring points installed at two depths, a shallow screened interval monitoring point and a deep screened monitoring point. The depth of the shallow monitoring point will be placed between 3 to 6 feet bgs, depending upon the elevation of ground water at each location. The top of the screened interval of the deep monitoring points will be placed 5 to 15 feet below the bottom of the screened interval of the shallow monitoring point. The depth of the deep monitoring point will be determined by the Parsons ES field scientist depending upon site conditions.

Locations with a single proposed monitoring point will be screened across the water table. Each monitoring point will have a screened interval of 1 meter.

3.3.2 Monitoring Point Installation Procedures

3.3.2.1 Pre-Placement Activities

All necessary digging, coring, and drilling permits will be obtained prior to mobilizing to the field. In addition, all utility lines will be located, and proposed drilling locations will be cleared prior to any intrusive activities. Responsibilities for these permits and clearances are discussed in Section 3.1.1.

Water to be used in monitoring point installation and equipment cleaning will be obtained from one of the Base water supplies. Water use approval will be verified by contacting the appropriate facility personnel. The field scientist will make the final determination as to the suitability of site water for these activities.

3.3.2.2 Monitoring Point Materials Decontamination

Monitoring point installation and completion materials will be inspected by the field scientist and determined to be clean and acceptable prior to use. If not factory sealed, the well points and tubing will be cleaned prior to use with a high-pressure, steam/hot-water cleaner using approved water. Materials that cannot be cleaned to the satisfaction of the field scientist will not be used.

3.3.2.3 Installation and Materials

This section describes the procedures to be used for installation of monitoring points. Monitoring points will be installed using either 0.375-inch Teflon® tubing connected to a 0.5-inch diameter stainless steel screen or a 0.5 inch inside-diameter (ID)/0.75 inch outside-diameter (OD) PVC screen and casing.

3.3.2.3.1 Deep Monitoring Points

The deep monitoring points will be installed in boreholes punched using the Geoprobe®. The deep monitoring points will be constructed of a sacrificial drive point attached to a length of 0.5-inch diameter stainless steel mesh that functions as the well screen, which is connected to 0.375-inch Teflon® tubing.

To install the deep monitoring points, the borehole is punched and sampled to several feet above the target depth for the monitoring point. The probe rods are

withdrawn from the borehole, and the soil sampler is replaced with the well point assembly. An appropriate length of Teflon® tubing is threaded through the probe rods and attached to the well point. The assembly is lowered into the borehole and then driven down to the target depth and sampling zone. The probe rods are removed, leaving the sacrificial tip, screen assembly and tubing behind. The saturated soil formation is likely to cave in around the screen assembly; where this does not occur, silica sand will be emplaced to create a sand pack around the well point. The borehole annular space around the tubing above the sand pack will be filled with granular bentonite or grout to seal it.

3.3.2.3.2 Shallow Monitoring Points

If subsurface conditions permit, shallow monitoring points will be constructed of 0.75-inch OD/0.5-inch ID PVC casing and well screen to provide additional water level information. Approximately 1 meter of factory-slotted screen will be installed for each shallow monitoring point. Effective installation of the shallow monitoring points requires that the boreholes remain open upon completion of drilling. Shallow 0.5-inch ID PVC monitoring points will be installed by punching and sampling a borehole with the Geoprobe®. Upon removing the rods, the borehole depth will be measured to determine if the hole is staying open. If the borehole remains open, the 0.5-inch ID PVC casing and screen will be placed at the appropriate depths. The annular space around the screen will be filled with sand filter pack, and the annulus around the casing will be filled with grout or bentonite. Monitoring point construction details will be noted on a Monitoring Point Installation Record form (Figure 3.6). This information will become part of the permanent field record for the site.

Temporary monitoring point screens will be constructed of flush-threaded, Schedule 40 PVC with an ID of 0.5 inch. The screens will be factory slotted with 0.01-inch openings. Monitoring point screens will be placed to sample and provide water level information at or near the water table. Blank monitoring point casing will be constructed of Schedule 40 PVC with an ID of 0.5-inch. All monitoring point casing sections will be flush-threaded; joints will not be glued. The casing at each monitoring point will be fitted with a bottom cap and a top cap constructed of PVC.

If subsurface conditions do not permit the boreholes to stay open (i.e. the formation collapses in the hole), shallow 0.5 inch-ID PVC monitoring points may be installed using the Geoprobe®. If the installation of 0.5-inch PVC monitoring points is not possible or is impractical using the Geoprobe®, monitoring points constructed of 0.375 inch Teflon® described in Section 3.2.2.3.1 will be utilized. Should 0.5-inch ID PVC shallow monitoring points not be installed, the only data gap resulting will be the lack of water level information for that particular location. The decision to install 0.5-inch ID PVC monitoring points will be made in the field once the open-hole stability of subsurface soils and Geoprobe® equipment can be evaluated.

MONITORING POINT INSTALLATION RECORD

JOB NAME MACDILL AIR FORCE BASE MONITORING POINT NUMBER _____
 JOB NUMBER 722450.21 INSTALLATION DATE _____ LOCATION _____
 DATUM ELEVATION _____ GROUND SURFACE ELEVATION _____
 DATUM FOR WATER LEVEL MEASUREMENT _____
 SCREEN DIAMETER & MATERIAL _____ SLOT SIZE _____
 RISER DIAMETER & MATERIAL _____ BOREHOLE DIAMETER _____
 CONE PENETROMETER CONTRACTOR _____ ES REPRESENTATIVE _____

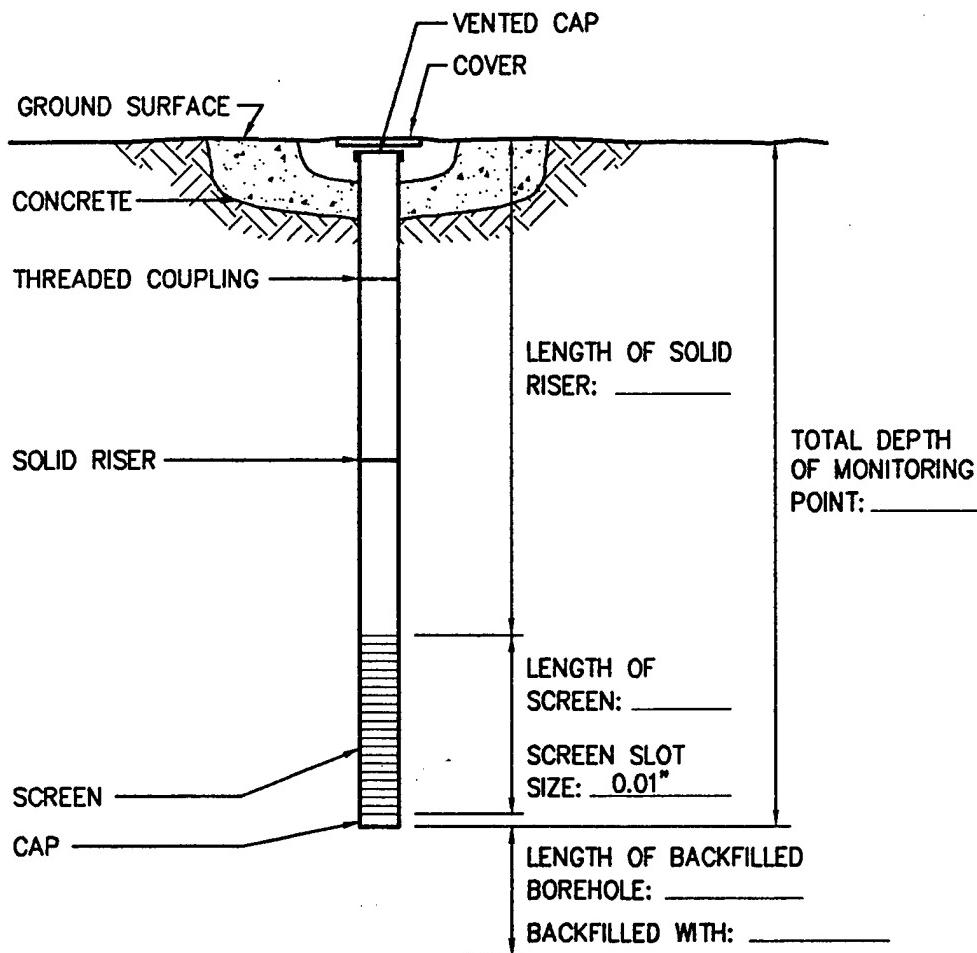


FIGURE 3.6

MONITORING POINT INSTALLATION RECORD

STABILIZED WATER LEVEL _____ FEET
BELOW DATUM.

TOTAL MONITORING POINT DEPTH _____ FEET
BELOW DATUM.

GROUND SURFACE _____ FEET

Intrinsic Remediation TS
MacDill Air Force Base, Florida

ENGINEERING-SCIENCE, INC.

Denver, Colorado

The field scientist will verify and record the total depth of the monitoring point, the lengths of all casing sections, and the depth to the top of all monitoring point completion materials. All lengths and depths will be measured to the nearest 0.1 foot.

3.3.2.4 Monitoring Point Completion

A number of the monitoring points will be completed abovegrade, and steel protective casing will be used to protect the well points from tampering and damage. Where pavement is present, an at-grade cover will be cemented in place using concrete blended into the existing pavement. Where pavement is not present, the protective cover will be raised slightly above the ground surface with a 1-foot square concrete pad that will slope gently away from the cover to facilitate runoff during precipitation events. The number of permanent monitoring points will be determined by the Parsons ES field scientist. The completion of the monitoring points will be similar to those protecting the existing monitoring wells unless otherwise specified by Base personnel.

3.3.2.5 Monitoring Point Abandonment and Site Restoration

After monitoring point installation and sampling is complete, each site will be restored as closely as possible to its original condition. Clean and contaminated development waters and sampling purge waters will be stored in 55-gallon drums provided by the Base and transported by Base personnel to the designated waste collection areas at the Base.

Those monitoring points not completed with an external casing will be abandoned. The PVC casing and screen or Teflon® tubing will be extracted as far as possible and discarded. While holes created by the Geoprobe® in sandy soils similar to those found at the Base tend to cave in soon after extraction of the drive rod, any test holes remaining open after extraction of the casing will be sealed with bentonite chips, pellets, or grout to eliminate any creation or enhancement of contaminant migration pathways to the ground water.

3.3.3 Monitoring Point Development and Records

The monitoring points will be developed prior to sampling to remove fine sediments from the portion of the formation adjacent to the well point screen. Development will be accomplished using a peristaltic pump provided by Parsons ES. The pump will be attached to the well point and water will be removed until pH, temperature, specific conductivity, and water clarity (turbidity) stabilize. Monitoring point development will occur a minimum of 24 hours prior to sampling.

Development waters will be collected in 55-gallon drums provided by the Base. Filled 55-gallon drums will be placed on pallets and transported by Base personnel to the designated waste collection area.

A development record will be maintained for each monitoring point. The development record will be completed in the field by the field scientist. Figure 3.7 is an example of a development record used for similar well installations. Development records will include:

- Monitoring point number;
- Date and time of development;
- Development method;
- Monitoring point depth;
- Volume of water produced;
- Description of water produced;
- Post development water level and monitoring point depth; and
- Field analytical measurements, including pH and specific conductivity.

3.3.4 Monitoring Point Location and Datum Survey

The location and elevation of the well points will be surveyed soon after completion. The horizontal location will be measured relative to established Base coordinates. Horizontal coordinates will be measured to the nearest 0.1 foot. The elevation of the ground surface adjacent to the protective casing will be measured relative to the USGS msl datum. The ground surface elevation will be measured to the nearest 0.1 foot. Because water levels cannot be measured through the well point tubing, no datum elevation, such as top of casing, will be measured.

3.3.5 Water Level Measurements

Water levels at existing monitoring wells and monitoring points will be measured within a short time period so that the water level data are comparable. The depth to water below the measurement datum will be measured to the nearest 0.01 foot using an electric water level probe.

3.4 GROUND WATER SAMPLING PROCEDURES

This section describes the scope of work required for collection of ground water quality samples at existing ground water monitoring wells and newly installed monitoring points. This section also details grab-sampling using peristaltic pumps inserted into the

MONITORING POINT DEVELOPMENT RECORD

Page ___ of ___

Job Number: _____
Location _____
Well Number _____Job Name: _____
By _____ Date _____
Measurement Datum _____Pre-Development Information

Time (Start):

Water Level:

Total Depth of Well:

Water Characteristics

Color _____	Clear	Cloudy
Odor: None	Weak	Moderate
Any Films or Immiscible Material _____		
pH _____	Temperature ($^{\circ}$ F $^{\circ}$ C) _____	
Specific Conductance (μ S/cm) _____		

Interim Water Characteristics

Gallons Removed

pH

Temperature ($^{\circ}$ F $^{\circ}$ C)Specific Conductance (μ S/cm)Post-Development Information

Time (Finish):

Water Level:

Total Depth of Well:

Approximate Volume Removed:

Water Characteristics

Color _____	Clear	Cloudy
Odor: None	Weak	Moderate
Any Films or Immiscible Material _____		
pH _____	Temperature ($^{\circ}$ F $^{\circ}$ C) _____	
Specific Conductance (μ S/cm) _____		

Comments:

FIGURE 3.7
**MONITORING POINT
DEVELOPEMENT RECORD**

Intrinsic Remediation TS
MacDill Air Force Base, Florida



**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

probe rods themselves to obtain single, discrete groundwater samples, if required. All ground water samples will be obtained using a peristaltic pump and dedicated Teflon®-lined, polyethylene tubing where groundwater levels permit. In order to maintain a high degree of QC during this sampling event, the procedures described in the following sections will be followed.

Sampling will be conducted by qualified scientists and technicians trained in the conduct of ground water sampling, records documentation, and chain-of-custody procedures. In addition, sampling personnel will have thoroughly reviewed this work plan prior to sample acquisition and will have a copy of the work plan available onsite for reference.

The following summarizes the activities that will occur during ground water sampling:

- Assembly and preparation of equipment and supplies;
- Inspection of the monitoring well or monitoring point integrity including:
 - Protective cover, cap, and lock,
 - External surface seal and pad,
 - Monitoring point stick-up, cap, and datum reference, and
 - Internal surface seal;
- Ground water sampling, including
 - Water level and product thickness measurements,
 - Visual inspection of sample water,
 - Monitoring point casing evacuation, and
 - Sample collection;
- Sample preservation and shipment, including
 - Sample preparation,
 - Onsite measurement of physical parameters, and
 - Sample labeling;
- Completion of sampling records; and
- Sample disposition.

Detailed ground water sampling and sample handling procedures are presented in following sections.

3.4.1 Ground Water Sampling Strategy

Ground water samples will be collected from existing monitoring wells and monitoring points installed during this project. The existing wells and proposed monitoring point locations for sampling are identified in the following sections. If site conditions prevent the installation of monitoring points, discrete grab samples will be acquired through the probe rod at each of the proposed monitoring point locations.

3.4.1.1 Site OT-24

At Site OT-24, the following existing wells will be sampled: MD 24-1, MD 24-2, MD 24-3, MD 24-4, MD 24-5, MD 24-6, MD 24-6A, MD 24-7, MD 24-8, MD 24-9, MD 24-10, and MD 24-10A. All newly installed monitoring points will be sampled also.

3.4.1.2 Pumphouse 75

All five existing monitoring wells, MD 75-01 through MD 75-05, will be sampled during this field effort. In addition, samples will be collected from the newly installed monitoring points.

3.4.1.3 Site 56

Monitoring wells MD56-MW01, MD56-MW02, MD56-MW03, MD56-MW04, MD-MW05, MD-MW06, and MD56-MW07 will be sampled as part of this field work. Samples will also be collected from the newly installed monitoring points.

3.4.2 Preparation for Sampling

All equipment to be used for sampling will be assembled and properly cleaned and calibrated (if required) prior to arriving in the field. In addition, all record-keeping materials will be gathered prior to leaving the office.

3.4.2.1 Equipment Cleaning

All portions of sampling and test equipment that will contact the sample matrix will be thoroughly cleaned before each use. This includes the Geoprobe® rods, water level probe and cable, lifting line, test equipment for onsite use, and other equipment or portions thereof that will contact the samples. Based on the types of sample analyses to be conducted, the following cleaning protocol will be used:

- Wash with potable water and phosphate-free laboratory detergent (HP-II detergent solutions, as appropriate);
- Rinse with potable water;
- Rinse with distilled or deionized water;
- Rinse with reagent-grade acetone; and,
- Air dry the equipment prior to use.

Any deviations from these procedures will be documented in the field scientist's field notebook and on the Ground Water Sampling Record (Figure 3.8).

If precleaned disposable sampling equipment is used, the cleaning protocol specified above will not be required. Laboratory-supplied sample containers will be cleaned and sealed by the laboratory. The type of container provided and the method of container decontamination will be documented in the laboratory's permanent record of the sampling event.

3.4.2.2 Equipment Calibration

As required, field analytical equipment will be calibrated according to the manufacturers' specifications prior to field use. This applies to equipment used for onsite measurements of oxygen, carbon dioxide, pH, electrical conductivity, temperature, reduction/oxidation potential, sulfate, nitrate, nitrite, ferrous iron (Fe^{2+}), total iron, ferric iron [$Fe^{3+} = (\text{total iron}) - Fe^{2+}$], and manganese.

3.4.3 Sampling Procedures

Special care will be taken to prevent contamination of the ground water and extracted samples. The two primary ways in which sample contamination can occur are through contact with improperly cleaned equipment and through cross-contamination due to insufficient cleaning of equipment between wells and monitoring points. To prevent such contamination, the water level probe and cable used to determine static water levels and total well depths will be thoroughly cleaned before and after field use and between uses at different sampling locations according to the procedures presented in Section 3.3.2.1. In addition to the use of properly cleaned equipment, dedicated Teflon®-lined, polyethylene tubing will be used at each sampling point, and a clean pair of new, disposable nitrile or latex gloves will be worn each time a different well or monitoring point is sampled. The following paragraphs present the procedures to be followed for ground water sample collection from ground water monitoring wells and monitoring points. These activities will be performed in the order presented below. Exceptions to this procedure will be noted in the sampler's field notebook and the ground water sampling form.

SAMPLING LOCATION _____
SAMPLING DATE(S) _____

GROUND WATER SAMPLING RECORD - MONITORING WELL _____

(number)

REASON FOR SAMPLING: [] Regular Sampling; [] Special Sampling;

DATE AND TIME OF SAMPLING: _____, 19_____ a.m./p.m.

SAMPLE COLLECTED BY: _____ of _____

WEATHER: _____

DATUM FOR WATER DEPTH MEASUREMENT (Describe): _____

MONITORING WELL CONDITION:

[] LOCKED:

[] UNLOCKED

WELL NUMBER (IS - IS NOT) APPARENT

STEEL CASING CONDITION IS: _____

INNER PVC CASING CONDITION IS: _____

WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT

[] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR

[] MONITORING WELL REQUIRED REPAIR (describe): _____

Check-off

1 []

EQUIPMENT CLEANED BEFORE USE WITH _____

Items Cleaned (List): _____

2 []

PRODUCT DEPTH _____ FT. BELOW DATUM

Measured with: _____

WATER DEPTH _____ FT. BELOW DATUM

Measured with: _____

3 []

WATER-CONDITION BEFORE WELL EVACUATION (Describe):

Appearance: _____

Odor: _____

Other Comments: _____

4 []

WELL EVACUATION:

Method: _____

Volume Removed: _____

Observations: Water (slightly - very) cloudy

Water level (rose - fell - no change)

Water odors: _____

Other comments: _____

FIGURE 3.8

GROUND WATER
SAMPLING RECORD



5 [] SAMPLE EXTRACTION METHOD:

- [] Bailer made of: _____
 [] Pump, type: _____
 [] Other, describe: _____

Sample obtained is [] GRAB; [] COMPOSITE SAMPLE

6 [] ON-SITE MEASUREMENTS:

- | | |
|-------------------------|----------------------|
| Temp: _____ | Measured with: _____ |
| pH: _____ | Measured with: _____ |
| Conductivity: _____ | Measured with: _____ |
| Dissolved Oxygen: _____ | Measured with: _____ |
| Redox Potential: _____ | Measured with: _____ |
| Salinity: _____ | Measured with: _____ |
| Nitrate: _____ | Measured with: _____ |
| Sulfate: _____ | Measured with: _____ |
| Ferrous Iron: _____ | Measured with: _____ |
| Other: _____ | _____ |

7 [] SAMPLE CONTAINERS (material, number, size): _____

8 [] ON-SITE SAMPLE TREATMENT:

- [] Filtration: Method _____ Containers: _____
 Method _____ Containers: _____
 Method _____ Containers: _____

[] Preservatives added:

- | | |
|--------------|-------------------|
| Method _____ | Containers: _____ |

9 [] CONTAINER HANDLING:

- [] Container Sides Labeled
 [] Container Lids Taped
 [] Containers Placed in Ice Chest

10 [] OTHER COMMENTS: _____

_____FIGURE 3.8
(Continued)GROUND WATER
SAMPLING RECORDIntrinsic Remediation TS
MacDill Air Force Base, FloridaPARSONS
ENGINEERING SCIENCE, INC.

Denver, Colorado.

3.4.3.1 Preparation of Location

Prior to starting the sampling procedure, the area around the existing wells and new monitoring points will be cleared of foreign materials, such as brush, rocks, and debris. These procedures will prevent sampling equipment from inadvertently contacting debris around the monitoring well/point.

3.4.3.2 Water Level and Total Depth Measurements

Prior to removing any water from the monitoring well or monitoring point, the static water level will be measured. An electric water level probe will be used to measure the depth to ground water below the datum to the nearest 0.01 foot. After measuring the static water level, the water level probe will be slowly lowered to the bottom of the monitoring well/point and the depth will be measured to the nearest 0.01 foot. Based on these measurements, the volume of water to be purged from the monitoring well/point will be calculated. If free-phase product is encountered, the thickness of the product will be measured.

3.4.3.3 Purging Before Sampling

The volume of water contained within the monitoring well/monitoring point casing at the time of sampling will be calculated, and three times the calculated volume will be removed from the well/monitoring point. All purge water will be placed in 55-gallon drums and disposed of by Base personnel at the Base's approved disposal location. Emptied 55-gallon drums will be handled by Base personnel. A peristaltic pump will be used for all purging since ground water is shallow at the Base.

If a monitoring well/monitoring point is evacuated to a dry state during purging, the monitoring well/monitoring point will be allowed to recharge, and the sample will be collected as soon as sufficient water is present in the monitoring well or monitoring point to obtain the necessary sample quantity. Sample compositing or sampling over a lengthy period by accumulating small volumes of water at different times to obtain a sample of sufficient volume will not be allowed.

The installed well points require minimal purging before sampling because the water in the well point tubing has little contact with the atmosphere. The sampler will pump enough water to ensure that the water in the tubing has been changed several times and that specific conductance and pH stabilize.

3.4.3.4 Sample Extraction

Dedicated, Teflon®-lined, high-density polyethylene (HDPE) tubing and a peristaltic pump will be used to extract ground water samples from the monitoring wells and monitoring points. The tubing will be lowered through the well and 0.5-inch ID PVC monitoring point casing into the water gently to prevent splashing. The tubing from the monitoring points constructed of 0.375-inch Teflon® tubing will be connected directly to the peristaltic pump. The sample will be transferred directly into the appropriate sample container. The water will be carefully poured down the inner walls of the sample bottle to minimize aeration of the sample.

At locations where the installation of monitoring points is found to be impossible, inefficient, or inadequate to acquire a credible ground water sample, grab ground water sampling will be performed using the Geoprobe®, peristaltic pump, and Teflon®-lined HDPE tubing. The tubing will be lowered into the push rod fitted with a slotted tip and a discrete ground water sample will be acquired.

Unless other instructions are given by the analytical laboratory, sample containers will be completely filled so that no air space remains in the container. Excess water collected during sampling will be placed into the 55-gallon drums used for monitoring well/monitoring point purge waters and transported for disposal by Base personnel to the on-Base facilities

3.4.4 Onsite Ground Water Parameter Measurement

As indicated on Table 3.1, many of the ground water chemical parameters will be measured onsite by Parsons ES personnel. Some of the measurements will be made with direct-reading meters, while others will be made using of a HACH® portable colorimeter in accordance with specific HACH® analytical procedures. These procedures will be described in the following subsections.

All glassware or plasticware used in the analyses will have been cleaned prior to sample collection by thoroughly washing with a solution of Alconox® and water, and rinsing with deionized water and ethanol to prevent interference or cross contamination between measurements. If concentrations of an analyte are above the range detectable by the titrimetric method, the analysis will be repeated by diluting the groundwater sample with double-distilled water until the analyte concentration falls to a level within the range of the method. All rinseate and sample reagents accumulated during groundwater analysis will be collected in glass containers fitted with screw caps. These waste containers will be clearly labeled as to their contents and carefully stored for later transfer by Base personnel to the approved disposal facility.

3.4.4.1 Dissolved Oxygen (DO) Measurements

DO measurements will be made using a meter with a downhole oxygen sensor or a sensor in a flow-through cell. Measurements will be taken before and immediately following ground water sample acquisition. When DO measurements are taken in monitoring wells/points that have not yet been sampled, the existing monitoring wells/points will be purged until DO levels stabilize. DO measurements will be recorded on the ground water sampling record (Figure 3.8)

3.4.4.2 pH, Temperature, and Specific Conductance

Because the pH, temperature, and specific conductance of a ground water sample can change significantly within a short time following sample acquisition, these parameters will be measured in the field in unfiltered, unpreserved, "fresh" water collected by the same technique as the samples taken for laboratory analyses. The measurements will be made in a clean glass container separate from those intended for laboratory analysis, and the measured values will be recorded in the ground water sampling record (Figure 3.8).

3.4.4.3 Alkalinity Measurements

Alkalinity in ground water helps buffer the ground water system against acids generated through both aerobic and anaerobic biodegradation processes. Alkalinity of the ground water sample will be measured in the field by experienced Parsons ES scientists via titrimetric analysis using EPA-approved HACH® Method 8221 (0 to 5,000 mg/L as calcium carbonate).

3.4.4.4 Carbon Dioxide Measurements

Carbon dioxide concentrations in ground water will be measured in the field by experienced Parsons ES scientists via titrimetric analysis using the CHEMetrics® Method 4500-CO₂C (10 to 100 ppm as CO₂).

3.4.4.5 Nitrate- and Nitrite-Nitrogen Measurements

Nitrate-nitrogen concentrations are of interest because nitrate can act as an electron acceptor during hydrocarbon biodegradation under anaerobic soil or ground water conditions. Nitrate-nitrogen is also a potential nitrogen source for biomass formation for hydrocarbon-degrading bacteria. Nitrite-nitrogen is an intermediate byproduct in both ammonia nitrification and in nitrate reduction in anaerobic environments.

Nitrate- and nitrite-nitrogen concentrations in ground water will be measured in the field by experienced Parsons ES scientists via colorimetric analysis using a HACH®

DR/700 Portable Colorimeter. Nitrate concentrations in ground water samples will be analyzed after preparation with HACH® Method 8039 (0 to 30.0 mg/L nitrate). Nitrite concentrations in ground water samples will be analyzed after preparation with EPA-approved HACH® Method 8507 (0 to 0.35 mg/L nitrite).

3.4.4.6 Sulfate and Sulfide Sulfur Measurements

Sulfate in ground water is a potential electron acceptor for fuel-hydrocarbon biodegradation in anaerobic environments, and sulfide is resultant after sulfate reduction. The Parsons ES scientist will measure sulfate and sulfide concentrations via colorimetric analysis with a HACH® DR/700 Portable Colorimeter after appropriate sample preparation. EPA-approved HACH® Methods 8051 (0 to 70.0 mg/L sulfate) and 8131 (0.60 mg/L sulfide) will be used to prepare samples and analyze sulfate and sulfide concentrations, respectively.

3.4.4.7 Total Iron, Ferrous Iron, and Ferric Iron Measurements

Iron is an important trace nutrient for bacterial growth, and different states of iron can affect the reduction/oxidation potential of the groundwater and act as an electron acceptor for biological metabolism under anaerobic conditions. Iron concentrations will be measured in the field via colorimetric analysis with a HACH® DR/700 Portable Colorimeter after appropriate sample preparation. HACH® Method 8008 for total soluble iron (0 to 3.0 mg/L ferric + ferrous iron) and HACH® Method 8146 for ferrous iron (0 to 3.0 mg/L) will be used to prepare and quantitate the samples. Ferric iron will be quantitated by subtracting ferrous iron levels from total iron levels.

3.4.4.8 Manganese Measurements

Manganese is a potential electron acceptor under anaerobic environments. Manganese concentrations will be quantitated in the field using colorimetric analysis with a HACH® DR/700 Portable Colorimeter. EPA-approved HACH® Method 8034 (0 to 20.0 mg/L) will be used to prepare the samples for quantitation of manganese concentrations. Sample preparation and disposal procedures are outlined earlier in Section 3.3.4.

3.4.4.9 Reduction/Oxidation Potential

The reduction/oxidation (redox) potential of ground water is an indicator of the relative tendency of a solution to accept or transfer electrons. Redox reactions in ground water are usually biologically mediated; therefore, the redox potential of a ground water system depends upon and influences rates of biodegradation. Redox potential can be used to provide real time data on the location of the contaminant plume, especially in areas undergoing anaerobic biodegradation. The redox potential of a ground water sample

taken inside the contaminant plume should have a redox potential somewhat less than that taken in the upgradient location.

The redox potential of a ground water sample can change significantly within a short time following sample acquisition and exposure to atmospheric oxygen. As a result, this parameter will be measured in the field in unfiltered, unpreserved, "fresh" water collected by the same technique as the samples taken for laboratory analyses. The measurements will be made as quickly as possible in a clean glass container separate from those intended for laboratory analysis.

3.5 HANDLING OF SAMPLES FOR LABORATORY ANALYSIS

This section describes the procedures for sample handling from the time of sampling until the samples arrive at the laboratory.

3.5.1 Sample Preservation

The analytical laboratory support personnel will add any necessary chemical preservatives prior to shipping the containers to the site. Samples will be prepared for transportation to the analytical laboratory by placing the samples in a cooler containing ice to maintain a shipping temperature of 4 degrees centigrade (°C). Samples will be delivered to the analytical laboratory via overnight courier so that all sample holding times are met.

3.5.2 Sample Container and Labels

Sample containers and appropriate container lids will be provided by the analytical laboratory (see Appendix A). The sample containers will be filled as described in Section 3.3.3.2.4, and the container lids will be tightly closed. The sample label will be firmly attached to the container side, and the following information will be legibly and indelibly written on the label:

- Facility name;
- Sample identification;
- Sample type (e.g., ground water);
- Sampling date;
- Sampling time;
- Preservatives added;
- Sample collector's initials; and

- Requested analyses.

3.5.3 Sample Shipment

After the samples are sealed and labeled, they will be packaged for transport to the mobile laboratory. The following packaging and labeling procedures will be followed:

- Package sample so that it will not leak, spill, or vaporize from its container;
- Cushion samples to avoid breakage; and
- Add ice to container to keep samples cool.

The packaged samples will be delivered by overnight courier to the analytical laboratory. Delivery will occur as soon as possible after sample acquisition.

3.3.5.4 Chain-of-Custody Control

After the samples have been collected, chain-of-custody procedures will be followed to establish a written record of sample handling and movement between the sampling site and the analytical laboratory. Each shipping container will have a chain-of-custody form completed in triplicate by the sampling personnel. One copy of this form will be kept by the sampling contractor after sample delivery to the analytical laboratory, and the other two copies will be retained at the laboratory. One of the laboratory copies will become a part of the permanent record for the sample and will be returned with the sample analytical results. The chain-of-custody will contain the following information:

- Sample identification number;
- Sample collectors' printed names and signatures;
- Date and time of collection;
- Place and address of collection;
- Sample matrix;
- Chemical preservatives added;
- Analyses requested;
- Signatures of individuals involved in the chain of possession; and
- Inclusive dates of possession

The chain-of custody documentation will be placed inside the shipping container so that it will be immediately apparent to the laboratory personnel receiving the container, but will not be damaged or lost during transport. The shipping container will be sealed so that it will be obvious if the seal has been tampered with or broken.

3.3.5.5 Sampling Records

In order to provide complete documentation of the sampling event, detailed records will be maintained by the field scientist. At a minimum, these records will include the following information:

- Sample location (facility name);
- Sample identification;
- Sample location map or detailed sketch;
- Date and time of sampling;
- Sampling method;
- Field observations of
 - Sample appearance, and
 - Sample odor;
- Weather conditions;
- Water level prior to purging (ground water samples only);
- Total monitoring well/monitoring point depth (ground water samples only);
- Sample depth (soil and sediment samples only);
- Purge volume (ground water samples only);
- Water level after purging (ground water samples only);
- Monitoring well/point condition (ground water samples only);
- Sampler's identification;
- Field measurements of pH, temperature, dissolved oxygen, and specific conductivity (ground water samples only), and
- Any other relevant information.

Ground water sampling information will be recorded on a ground water sampling form. Figure 3.8 shows an example of the ground water sampling record. Soil sampling information will be recorded in the field log book.

3.3.6 Laboratory Analyses

Laboratory analyses will be performed on all ground water, surface water, soil, and sediment samples and the QA/QC samples described in Section 5. The analytical methods for this sampling event are listed in Table 3.1. Prior to sampling, arrangements will be made with the analytical laboratory to provide a sufficient number of appropriate sample containers for the samples to be collected. All containers, preservatives, and shipping requirements will be consistent with EPA protocol or those reported in Appendix A of this plan.

Analytical laboratory support personnel will specify the necessary QC samples and prepare appropriate QC sample bottles. For samples requiring chemical preservation, preservatives will be added to containers by the laboratory prior to delivery to the site. Containers, ice chests with adequate padding, and cooling media may be sent by the laboratory to the site. Sampling personnel will fill the sample containers and return the samples to the laboratory.

3.6 AQUIFER TESTING

Slug tests will be conducted on selected existing wells to estimate the hydraulic conductivity of the unconsolidated materials each of the three sites. This information is required to accurately estimate the velocity of ground water and contaminants in the shallow saturated zone. A slug test is a single-well hydraulic test used to determine the hydraulic conductivity of an aquifer in the immediate vicinity of the tested well. Slug tests can be used for both confined and unconfined aquifers that have a transmissivity of less than 7,000 ft²/day. Slug testing can be performed using either a rising head or a falling head test; at this site, both methods will be used in sequence.

3.6.1 Definitions

- **Hydraulic Conductivity (K).** A quantitative measure of the ability of porous material to transmit water; defined as the volume of water that will flow through a unit cross-sectional area of porous or fractured material per unit time under a unit hydraulic gradient.
- **Transmissivity (T).** A quantitative measure of the ability of an aquifer to transmit water. It is the product of the hydraulic conductivity and the saturated thickness.

- **Slug Test.** Two types of testing are possible: rising head and falling head tests. A slug test consists of adding a slug of water or a solid cylinder of known volume to the well to be tested or removing a known volume of water or cylinder and measuring the rate of recovery of water level inside the well. The slug of a known volume acts to raise or lower the water level in the well.
- **Rising Head Test.** A test used in an individual well within the saturated zone to estimate the hydraulic conductivity of the surrounding formation by lowering the water level in the well and measuring the rate of recovery of the water level. The water level may be lowered by pumping, bailing, or removing a submerged slug from the well.
- **Falling Head Test.** A test used in an individual well to estimate the hydraulic conductivity of the surrounding formation by raising the water level in the well by insertion of a slug or quantity of water, and then measuring the rate of drop in the water level.

3.6.2 Equipment

The following equipment is needed to conduct a slug test:

- Teflon®, PVC, or metal slugs;
- One-quarter-inch nylon or polypropylene rope;
- Electric water level indicator;
- Pressure transducer/sensor;
- Field logbook/forms; and
- Automatic data recording instrument (such as the Hermit Environmental Data Logger®, In-Situ, Inc. Model SE1000B, or equivalent).

3.6.3 General Test Methods

Aquifer hydraulic conductivity tests (slug tests) are accomplished by either removal of a slug or quantity of water (rising head) or introduction of a slug (falling head), and then allowing the water level to stabilize while taking water level measurements at closely spaced time intervals.

Because hydraulic testing will be completed on existing wells, it will be assumed that the wells were properly developed and that water levels have stabilized. Slug testing

will proceed only after water level measurements show that static water levels are in equilibrium. During the slug test, the water level change should be influenced only by the introduction (or removal) of the slug volume. Other factors, such as inadequate well development or extended pumping may lead to inaccurate results. The field scientist will determine when static equilibrium has been reached in the well. The pressure transducer, slugs, and any other downhole equipment will be decontaminated prior to and immediately after the performance of each slug test using the procedures described in Section 3.3.2.1.

3.6.4 Falling Head Test

The falling head test is the first step in the two-step slug-testing procedure. The following steps describe procedures to be followed during performance of the falling head test.

1. Decontaminate all downhole equipment prior to initiating the test.
2. Open the well. Where wells are equipped with water tight caps, the well should be unsealed at least 24 hours prior to testing to allow the water level to stabilize. The protective casing will remain locked during this time to prevent vandalism.
3. Prepare the Aquifer Slug Test Data Form (Figure 3.9) with entries for:
 - Borehole/well number,
 - Project number,
 - Project name,
 - Aquifer testing team,
 - Climatic data,
 - Ground surface elevation,
 - Top of well casing elevation,
 - Identification of measuring equipment being used,
 - Page number,
 - Static water level, and
 - Date.
4. Measure the static water level in the well to the nearest 0.01 foot.

Aquifer Slug Test Data Sheet

Location _____
Job No. _____
Water Level _____
Measuring Datum _____
Weather _____
Comments _____

Client _____ Well No. _____
Field Scientist _____ Date _____
Total Well Depth _____
Elevation of Datum _____
Temp _____

FIGURE 3.9

**AQUIFER SLUG
TEST DATA FORM**

Intrinsic Remediation TS
MacDill Air Force Base, Florida



**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

5. Lower the decontaminated pressure transducer into the well and allow the displaced water to return to its static level. This can be determined by periodic water level measurements until the static water level in the well is within 0.01 foot of the original static water level.
6. Lower the decontaminated slug into the well to just above the water level in the well.
7. Turn on the data logger and quickly lower the slug below the water table, being careful not to disturb the pressure transducer. Follow the owner's manual for proper operation of the data logger.
8. Terminate data recording when the water level stabilizes in the well.

3.6.5 Rising Head Test

After completion of the falling head test, the rising head test will be performed. The following steps describe the rising head slug test procedure.

1. Measure the water level in the well to the nearest 0.01 foot to ensure that it has returned to the static water level.
2. Initiate data recording and quickly withdraw the slug from the well. Follow the owner's manual for proper operation of the data logger.
3. Terminate data recording when the water level stabilizes in the well, and remove the pressure transducer from the well and decontaminate.

3.6.6 Slug Test Data Analysis

Data obtained during slug testing will be analyzed using AQTESOLV™ and the method of Hvorslev (1951) for confined aquifers or the method of Bouwer and Rice (1976) and Bouwer (1989) for unconfined conditions.

SECTION 4

REMEDIAL OPTION EVALUATION AND TS REPORT

Upon completion of field work, the Bioplume II numerical ground water model will be used to determine the fate and transport of fuel hydrocarbons dissolved in ground water at the three sites. Based upon model predictions of contaminant concentration and distribution through time, and upon potential exposure pathways, the potential risk to human health and the environment will be assessed. If it is shown that intrinsic remediation of BTEX compounds at the site is sufficient to reduce the potential risk to human health and the environment to acceptable levels, Parsons ES will recommend implementation of the intrinsic remediation option. If intrinsic remediation is chosen, Parsons ES will prepare a site-specific, long-term monitoring plan that will specify the location of point-of-compliance monitoring wells and sampling frequencies.

If the intrinsic remediation remedial option is deemed inappropriate for use at this site, institutional controls such as ground water or land use restrictions will be evaluated to determine if they will be sufficient to reduce the risk to human health and the environment to acceptable levels. If institutional controls are inappropriate, remedial options which could reduce risks to acceptable levels will be evaluated and the most appropriate remedial options will be recommended. Potential remedial options include, but are not limited to, free-product recovery, ground water pump-and-treat, enhanced biological treatment, bioventing, air sparging, and *in situ* reactive barrier walls. The reduction in dissolved BTEX that should result from remedial activities will be used to produce a new input file for the Bioplume II model. The model will then be used to predict the BTEX plume (and risk) reduction that should result from remedial actions.

Upon completion of Bioplume II modeling and remedial option selection, a TS report detailing the results of the modeling and remedial option selection will be prepared. This report will follow the outline presented in Table 4.1 and will contain an introduction, site descriptions, identification of remediation objectives, description of remediation alternatives, an analysis of remediation alternatives, and the recommended remedial approach for each site. This report will also contain the results of the site characterization activities described herein and a description of the Bioplume II model developed for this site.

TABLE 4.1
EXAMPLE TS REPORT OUTLINE
MACDILL AFB, FLORIDA

INTRODUCTION

- Scope and Objectives
- Site Background

SITE CHARACTERIZATION ACTIVITIES

- CPT, Sampling, and Aquifer Testing Procedures

PHYSICAL CHARACTERISTICS OF THE STUDY AREA

- Surface Features
- Regional Geology and Hydrogeology
- Site Geology and Hydrogeology
- Climatological Characteristics

NATURE AND EXTENT OF CONTAMINATION

- Source Characterization
- Soil Chemistry
 - Residual-Phase Contamination
 - Total Organic Carbon
- Ground Water Chemistry
 - LNAPL Contamination
 - Dissolved Contamination
 - Ground Water Geochemistry
 - Expressed Assimilative Capacity

GROUND WATER MODEL

- Model Description
- Conceptual Model Design and Assumptions
- Initial Model Setup
- Model Calibration
- Sensitivity Analysis
- Model Results
- Conclusions

COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

- Remedial Alternative Evaluation Criteria
 - Long-Term Effectiveness
 - Implementability (Technical, Administrative)
 - Cost (Capital, Operating, Present Worth)
- Factors Influencing Alternatives Development
 - Program Objectives
 - Contaminant Properties
 - Site-Specific Conditions
- Brief Description of Remedial Alternatives
 - Intrinsic Remediation with Long-Term Monitoring
 - Other Alternatives

TABLE 4.1 (Continued)
EXAMPLE TS REPORT OUTLINE
MACDILL AFB, FLORIDA

Evaluation of Alternatives
Recommended Remedial Approach

LONG-TERM MONITORING PLAN

Overview
Monitoring Networks
Ground Water Sampling

CONCLUSIONS AND RECOMMENDATIONS

How does the recommended technology offer adequate protection for less cost.

APPENDICES: Supporting Data and Documentation
Site-Specific Bioplume II Model Input and Results

SECTION 5

QUALITY ASSURANCE/QUALITY CONTROL

Field QA/QC procedures will include collection of field duplicates and rinseate, field and trip blanks; decontamination of all equipment contacts that the sample medium before and after each use; use of analyte-appropriate containers; and chain-of-custody procedures for sample handling and tracking. All samples to be transferred to the analytical laboratory for analysis will be clearly labeled to indicate sample number, location, matrix (e.g., ground water), and analyses requested. Samples will be preserved in accordance with the analytical methods to be used, and water sample containers will be packaged in coolers with ice to maintain a temperature of 4°C.

All field sampling activities will be recorded in a bound, sequentially paginated field notebook in permanent ink. All sample collection entries will include the date, time, sample locations and numbers, notations of field observations, and the sampler's name and signature. Field QC samples will be collected in accordance with the program described below, and as summarized in Table 5.1.

QA/QC sampling will include collection and analysis of duplicate ground water and soil samples, rinseate blanks, field/trip blanks, and matrix spike samples. Internal laboratory QC analyses will involve the analysis of laboratory control samples (LCSs) and laboratory method blanks (LMBs). QA/QC objectives for each of these samples, blanks, and spikes are described below.

Soil and ground water samples collected with the Geoprobe sampler should provide sufficient volume for some duplicate analyses. Refer to Table 3.1 and Appendix A for further details on sample volume requirements.

One rinseate sample will be collected for every 10 or fewer ground water samples collected from existing wells. Because disposable bailers may be used for this sampling event, the rinseate sample will consist of a sample of distilled water poured into a new disposable bailer and subsequently transferred into a sample container provided by the laboratory. Rinseate samples will be analyzed for VOCs only.

A field blank will be collected for every 20 or fewer ground water samples (both from ground water monitoring point and existing ground water monitoring well sampling events) to assess the effects of ambient conditions in the field. The field blank will

TABLE 5.1
QA/QC SAMPLING PROGRAM
INTRINSIC REMEDIATION TS
MACDILL AIR FORCE BASE, FLORIDA

QA/QC Sample Types	Frequency to be Collected and/or Analyzed	Analytical Methods
Duplicates/Replicates	10% of Samples per Matrix a/	VOCs, TPH
Rinseate Blanks	10% of Ground Water Samples a/	VOCs
Field Blanks	5% of Ground Water Samples a/	VOCs
Trip Blanks	One per shipping cooler containing VOC samples	VOCs
Matrix Spike Samples	Once per sampling event	VOCs
Laboratory Control Sample	Once per method per medium	Laboratory Control Charts (Method Specific)
Laboratory Method Blanks	Once per method per medium	Laboratory Control Charts (Method Specific)

a/ Rounded to the next highest whole number.

consist of a sample of distilled water poured into a laboratory-supplied sample container while sampling activities are underway. The field blank will be analyzed for VOCs.

A trip blank will be analyzed to assess the effects of ambient conditions on sampling results during the transportation of samples. The trip blank will be prepared by the laboratory. A trip blank will be transported inside each cooler which contains samples for VOC analysis. Trip blanks will be analyzed for VOCs.

Matrix spikes will be prepared in the laboratory and used to establish matrix effects for samples analyzed for VOCs.

LCSs and LMBs will be prepared internally by the laboratory and will be analyzed each day samples from the site are analyzed. Samples will be reanalyzed in cases where the LCS or LMB are out of the control limits. Control charts for LCSs and LMBs will be developed by the laboratory and monitored for the analytical methods used.

SECTION 6

REFERENCES

- Black and Veatch Waste Science, Inc., In Preparation, *excerpts from Contamination Assessment Report for MacDill Air Force Base*, to be completed mid-1995.
- Borden, R.C., and Bedient, P.B. 1986. "Transport of Dissolved Hydrocarbons Influenced by Oxygen Limited Biodegradation 'Theoretical Development,'" *Water Resources Research*, vol. 22, no. 13. p. 1973-82.
- Bouwer, H., 1989, The Bouwer and Rice slug test - an update: *Ground Water*, 27(3), p. 304-309.
- Bouwer, H., and Rice, R.C., 1976, A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells: *Water Resources Research*, 12(3), p. 423-428.
- Bruce, L., Miller, T., and Hockman, B., 1991, Solubility versus equilibrium saturation of gasoline compounds - a method to estimate fuel/water partition coefficient using solubility or K_{oc} ... In, A. Stanley (editor), NWWAI/API Conference on Petroleum Hydrocarbons in Ground water: NWT/API, p. 571-582.
- CH2M Hill, 1990, U.S. Air Force Installation Restoration Program Contamination Assessment for Site 24, MacDill Air Force Base, April 1990.
- CH2M Hill, 1991a, U.S. Air Force Installation Restoration Program Contamination Assessment Report Addendum for OT-24(Site 24), MacDill Air Force Base, April 1991.
- CH2M Hill, 1991b, U.S. Air Force Installation Restoration Program Remedial Action Plan for Site OT-24, MacDill Air Force Base, May 1991.
- Cline, P.V., Delfino, J.J., and Rao, P.S.C., 1991, Partitioning of aromatic constituents into water from gasoline and other complex solvent mixtures: *Environmental Science and Technology*: v. 17, no. 4, p. 227-231.
- Driscoll, F.G., Groundwater and Wells, Second Edition: Johnson Filtration Systems, Inc., St. Paul, MN, 1986.
- Engineering-Science, Inc. (ES), 1993, Health and Safety Plan for the Bioplume Modeling Initiative. Prepared for the Air Force Center for Environmental Excellence, Environmental Restoration Division, USAF Contract F41624-92-D-8036.

- Espenshade, E.B., Goode's World Atlas, 17th Edition: Rand MacNally & Company, San Francisco, CA, 1986.
- Hvorslev, M. J., 1951, Time Lag and Soil Permeability in Ground-Water Observations: United States Corps of Engineers Waterways Experiment Station Bulletin 36, Vicksburg, Mississippi. 50 p.
- Lee, M.D. 1988. "Biorestoration of Aquifers Contaminated with Organic Compounds." *CRC Critical Reviews in Environmental Control*, v. 18. p. 29-89.
- Rafai, H.S., Bedient, P.B., Wilson, J.T., Miller, K.M., and Armstrong, J.M. 1988. "Biodegradation Modeling at Aviation Fuel Spill Site," *Journal of Environmental Engineering*, v. 114, no. 5, p. 1007-1029.
- US Geological Survey, 1987, 7.5 Minute Quadrangle Map of the Gibsonton Quadrangle, Florida.
- US Geological Survey, 1986, 7.5 Minute Quadrangle Map of the Port Tampa Quadrangle, Florida.
- Wiedemeier, Todd H., Downey, Douglas C., Wilson, John T., Campbell, Donald H., Miller, Ross N., and Hansen, Jerry E. In Progress. *Technical Protocol for Implementing the Intrinsic Remediation (Natural Attenuation) with Long-term Monitoring Option for Dissolved-phase Fuel Contamination in Ground Water*. Prepared by the Air Force Center for Environmental Excellence.

APPENDIX A

CONTAINERS, PRESERVATIVES, PACKAGING, AND SHIPPING REQUIREMENTS FOR GROUND WATER SAMPLES

Appendix A

Matrix	Analysis	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Soil	Volatile organics	Gas chromatography/mass spectrometry method SW8240.	Handbook method	Data is used to determine the extent of chlorinated solvent and aromatic hydrocarbon contamination, contaminant mass present, and the need for source removal.	Each sampling round	Collect 100 g of soil in a glass container with Teflon®-lined cap; cool to 4°C	Fixed-base
Soil	Dehydrogenase enzyme activity (optional)	Colorimetric RSKSOP-100	Reduction of added triphenyltetrazolium chloride by soil microbes is measured colorimetrically, analyze immediately	An indicator of the presence of soil microbes, which are necessary for bioremediation to occur	At the beginning of the project	Collect 100 g of soil in a glass container	Field
Soil	Aromatic hydrocarbons (benzene, toluene, ethylbenzene, and xylene [BTEX]; trimethylbenzene isomers)	Purge and trap gas chromatography (GC) method SW8020	Handbook method modified for field extraction of soil using methanol	Data is used to determine the extent of soil contamination, the contaminant mass present, and the need for source removal	Each sampling round	Collect 100 g of soil in a glass container with Teflon-lined cap; cool to 4°C	Fixed-base
Soil	Total hydrocarbons, volatile and extractable	GC method SW8015 [modified]	Handbook method, reference is the California LUFT manual	Data are used to determine the extent of soil contamination, the contaminant mass present, and the need for source removal	Each sampling round	Collect 100 g of soil in a glass container with Teflon-lined cap; cool to 4°C	Fixed-base

Appendix A (continued)

Matrix	Analysis	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Soil	Total organic carbon (TOC)	SW9060 modified for soil samples	Procedure must be accurate over the range of 0.5–15 percent TOC	Relatively high amounts of TOC may be indicative of a reducing environment and may indicate the need for analysis of electron acceptors associated with that environment; the rate of migration of petroleum contaminants in groundwater is dependent upon the amount of TOC in the saturated zone soil; the rate of release of petroleum contaminants from the source into groundwater is dependent (in part) on the amount of TOC in the vadose zone soil	At initial sampling	Collect 100 g of soil in a glass container with Teflon-lined cap; cool to 4°C	Fixed-base
Soil	Moisture	ASTM D-2216	Handbook method	Data are used to correct soil sample analytical results for moisture content (e.g., report results on a dry weight basis)	Each soil sampling round	Use a portion of soil sample collected for another analysis	Fixed-base
Soil	Grain size distribution	ASTM D422	Procedure provides a distribution of grain size by sieving	Data are used to infer hydraulic conductivity of aquifer, and are used in calculating sorption of contaminants	One time during life of project	Collect 250 g of soil in a glass or plastic container; preservation is unnecessary	Fixed-base
Soil gas	Carbon dioxide content of soil gas	Nondispersive infrared instrument operating over the range of approximately 0.1–15 percent	Soil gas carbon dioxide may be produced by the degradation of petroleum hydrocarbons	Each sampling round	N/A	Field	

Appendix A (continued)

Matrix	Analysis	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Soil gas	Oxygen content of soil gas	Electrochemical oxygen meter operating over the range of 0–25 percent of oxygen in the soil gas sample	The concentration of soil gas oxygen is often related to the amount of biological activity, such as the degradation of petroleum hydrocarbons; soil gas oxygen concentrations may decrease to the point where anaerobic pathways dominate	Data are used to understand the oxygen concentration gradient with depth and to determine the presence or absence of aerobic degradation processes	Each sampling round	N/A	Field
Soil gas	Methane content of soil gas	Total combustible hydrocarbon meter using a platinum catalyst with a carbon trap, and operating in the low parts per million volume (ppmv) range	Methane is a product of the anaerobic degradation of petroleum hydrocarbons	Soil gas methane can be used to locate contaminated soil and to determine the presence of anaerobic processes; see discussion of data use for methane in water	Each sampling round	N/A	Field
Soil gas	Fuel hydrocarbon vapor content of soil gas	Total combustible hydrocarbon meter operating over a wide ppmv range	Soil gas hydrocarbons indicate the presence of these contaminants in the soil column	Data used to understand the petroleum hydrocarbon concentration gradient with depth and to locate the most heavily contaminated soils	Each sampling round	N/A	Field
Water	Ferrous (Fe^{+2})	Colorimetric A3500-Fe D	Field only	May indicate an anaerobic degradation process due to depletion of oxygen, nitrate, and manganese	Each sampling round	Collect 100 mL of water in a glass container, acidify with hydrochloric acid per method.	Field
Water	Ferrous (Fe^{+2})	Colorimetric HACH Method # 8146	Alternate method; field only	Same as above	Each sampling round	Collect 100 mL of water in a glass container	Field

Appendix A (continued)

Matrix	Analysis	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Water	Total Iron	Colorimetric HACH Method # 8008	Field only		Each sampling round	Collect 100mL of water in a glass container	Field
Water	Manganese	Colorimetric HACH Method # 8034	Field only		Each sampling round	Collect 100 mL of water in a glass container	Field
Water	Chloride	Ion chromatography (IC) method E300 or method A4500-Cl ⁻ C		General water quality parameter used as a marker to verify that site samples are obtained from the same groundwater system.	Each sampling round	Collect 250 mL of water in a glass container	Field
Water	Chloride	HACH Chloride test kit model 8-P	Silver nitrate titration	Same as above	Each sampling round	Collect 100mL of water in a glass container	Field
Water	Oxygen	Dissolved oxygen meter	Refer to method A4500 for a comparable laboratory procedure	The oxygen concentration is a data input to the Biopluume model. Concentrations less than 1 mg/L generally indicate an anaerobic pathway.	Each sampling round	Collect 300 mL of water in biochemical oxygen demand bottles; analyze immediately; alternately, measure dissolved oxygen <i>in situ</i> .	Field
Water	Conductivity	E120.1/SW9050, direct reading meter	Protocols/Handbook methods	General water quality parameter used as a marker to verify that site samples are obtained from the same groundwater system.	Each sampling round	Collect 100–250 mL of water in a glass or plastic container	Field
Water	Alkalinity	HACH Alkalinity test kit model Al AP MG-L	Phenolphthalein method	General water quality parameter used (1) as a marker to verify that all site samples are obtained from the same groundwater system and (2) to measure the buffering capacity of groundwater	Each sampling round	Collect 100mL of water in glass container	Field

Appendix A (continued)

Matrix	Analysis	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Water	Akalinity	A2320, titrimetric; E310.2, colorimetric	Handbook method	Same as above	Each sampling round	Collect 250 mL of water in a glass or plastic container, analyze within 6 hours	Field
Water	Nitrate (NO_3^-)	IC method E300 or method SW9056; colorimetric, method E353.2	Method E300 is a Handbook method; method SW9056 is an equivalent procedure	Substrate for microbial respiration if oxygen is depleted	Each sampling round	Collect up to 40 mL of water in a glass or plastic container, cool to 4°C, analyze within 48 hours	Fixed-base
Water	Nitrate (NO_3^-)	HACH method # 8039 for high range method # 8192 for low range	Colorimetric	Same as above	Each sampling round	Collect 100mL of water in a glass container	Field
Water	Nitrite (NO_2^-)	HACH method #8040	Colorimetric	Substrate for microbial respiration if oxygen is depleted	Each sampling round	Collect 100mL of water in a glass container	Field
Water	Sulfate (SO_4^{2-})	IC method E300 or method SW9056	Method E300 is a Handbook method; method SW9056 is an equivalent procedure	Substrate for anaerobic microbial respiration	Each sampling round	Collect up to 40 mL of water in a glass or plastic container, cool to 4°C	Fixed-base
Water	Sulfate (SO_4^{2-})	HACH method # 8051	Colorimetric	Same as above	Each sampling round	Collect up to 40 mL of water in a glass or plastic container, cool to 4°C	Field
Water	Dissolved sulfide (S^{2-})	HACH method # 8131	Colorimetric	Product of sulfate-based anaerobic microbial respiration; analyze in conjunction with sulfate analysis	Each sampling round	Collect 100 mL of water in a glass container, analyze immediately	Field

Appendix A (continued)

Matrix	Analysis	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Water	Redox Potential	A2580B	Measurements are made with electrodes; results are displayed on a meter; samples should be protected from exposure to atmospheric oxygen	The redox potential of groundwater influences and is influenced by the nature of the biologically mediated degradation of contaminants; the redox potential of groundwater may range from more than 200 mV to less than -200 mV	Each sampling round	Collect 100–250 mL of water in a glass container; filling container from bottom; analyze immediately	Field
Water	Methane; carbon dioxide	RSKSOP-114 modified to analyze water samples for methane and carbon dioxide by headspace sampling with dual thermal conductivity and flame ionization detection (also, see reference in note 10)	Method published and used by the U.S. Environmental Protection Agency (EPA) Robert S. Kerr Laboratory	The presence of methane suggests BTEX degradation via an anaerobic pathway utilizing carbon dioxide (carbonate) as the electron acceptor (methanogenesis); a redox potential measurement of less than -200 mV could be indicative of methanogenesis and should be followed by the analysis referenced here; the presence of free carbon dioxide dissolved in groundwater is unlikely because of the carbonate buffering system of water, but if detected, the carbon dioxide concentrations should be compared with background to determine whether they are elevated; elevated concentrations of carbon dioxide could indicate an aerobic mechanism for bacterial degradation of petroleum	Each sampling round	Collect water samples in 40 mL volatile organic analysis (VOA) vials with butyl gray/Teflon-lined caps; cool to 4°C	Fixed-base

Appendix A (continued)

Matrix	Analysis	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Water	Ethane, ethene	RSKSOP-114 (cont'd)	Ethane and ethene are analyzed in addition to the other analytes only if chlorinated hydrocarbons are contaminants suspected of undergoing biological transformation	Ethane and ethene are products of the bio-transformation of chlorinated hydrocarbons under anaerobic conditions. The presence of these chemicals may indicate that anaerobic degradation is occurring			
Water	Carbon dioxide	HACH test kit model CA-23 or CHEMetrics Method 4500		The presence of free carbon dioxide dissolved in groundwater is unlikely because of the carbonate buffering system of water, but if detected, the carbon dioxide concentrations should be compared with background to determine whether they are elevated; elevated concentrations of carbon dioxide could indicate an aerobic mechanism for bacterial degradation of petroleum	Each sampling round	Collect 100 mL of water in a glass container	Field

Appendix A (continued)

Matrix	Analysis	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Water	Aromatic hydrocarbons (BTEX, trimethylbenzene isomers)	Purge and trap GC method SW8020	Handbook method; analysis may be extended to higher molecular weight alkyl benzenes	Method of analysis for BTEX, which is the primary target analyte for monitoring natural attenuation; BTEX concentrations must also be measured for regulatory compliance; method can be extended to higher molecular weight alkyl benzenes; trimethylbenzenes are used to monitor plume dilution if degradation is primarily anaerobic	Each sampling round	Collect water samples in a 40 mL VOA vial; cool to 4°C; add hydrochloric acid to pH 2	Fixed-base
Water	Total hydrocarbons, volatile and extractable	GC method SW8015 [modified]	Handbook method; reference is the California LUFT manual	Data used to monitor the reduction in concentrations of total fuel hydrocarbons (in addition to BTEX) due to natural attenuation; data also used to infer presence of an emulsion or surface layer of petroleum in water sample, as a result of sampling	One time per year or as required by regulations	Volatile hydrocarbons—collect water samples in a 40 mL VOA vial; cool to 4°C; add hydrochloric acid to pH 2 Extractable hydrocarbons—collect 1 L of water in a glass container; cool to 4°C; add hydrochloric acid to pH 2	Fixed-base
Water	Polycyclic aromatic hydrocarbons (PAHs) (optional)	GC/mass spectroscopy method SW8270, high-performance liquid chromatography method SW8310	PAHs are components of fuel and are typically analyzed for regulatory compliance; data on their concentrations are not used currently in the evaluation of natural attenuation	PAHs are components of fuel and are typically analyzed for regulatory compliance; data on their concentrations are not used currently in the evaluation of natural attenuation	At initial sampling and at site closure or as required by regulations	Collect 1 L of water in a glass container; cool to 4°C	Fixed-base

Appendix A (continued)

Matrix	Analysis	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Water	Total fuel carbon (optional)	Purge and trap GC method SW8020 modified to measure all volatile aromatic hydrocarbons present in the sample	A substitute method for measuring total volatile hydrocarbons, reports amount of fuel as carbon present in the sample; method available from the U.S. EPA Robert S. Kerr Laboratory	Data used to monitor the reduction in concentrations of total fuel hydrocarbons (in addition to BTEX) due to natural attenuation.	At initial sampling and at site closure	Collect 40 mL of water in glass vials with Teflon-lined caps; add sulfuric acid to pH 2, cool to 4°C	Fixed-base
Water	Volatile Organics	GS/MS method SW8240	Handbook method	Method of analysis for chlorinated solvents and aromatic hydrocarbons for evaluation of cometabolic degradation; measured for regulatory compliance when chlorinated solvents are known site contaminants	Each sampling round	Collect water samples in a 40 mL VOA vial; cool to 4°C; add hydrochloric acid to pH 2	Fixed-base
Water	Dissolved organic carbon (DOC) (optional)	AS3310 C	An oxidation procedure whereby carbon dioxide formed from DOC is measured by an infrared spectrometer. The minimum detectable amount of DOC is 0.05 mg/L	An indirect index of microbial activity	Each sampling round	Collect 100 mL of water in an amber glass container with Teflon-lined cap; preserve with sulfuric acid to pH less than 2, cool to 4°C	Fixed-base
Water	pH	E150.1/SW9040, direct reading meter	Protocols/Handbook methods	Aerobic and anaerobic processes are pH-sensitive	Each sampling round	Collect 100–250 mL of water in a glass or plastic container, analyze immediately	Field
Water	Temperature	E170.1	Field only	Well development	Each sampling round	N/A	Field

NOTES:

1. "HACH" refers to the HACH Company catalog, 1990.
2. "A" refers to *Standard Methods for the Examination of Water and Wastewater*, 18th edition, 1992.
3. "E" refers to *Methods for Chemical Analysis of Water and Wastes*, U.S. Environmental Protection Agency, March 1979.
4. "Protocols" refers to the AFCCEE *Environmental Chemistry Function Installation Restoration Program Analytical Protocols*, 11 June 1992.
5. "Handbook" refers to the AFCCEE *Handbook to Support the Installation Restoration Program (IRP) Remedial Investigations and Feasibility Studies (RI/FS)*, September 1993.
6. "SW" refers to the *Test Methods for Evaluating Solid Waste, Physical, and Chemical Methods*, SW-846, U.S. Environmental Protection Agency, 3rd edition, 1986.
7. "ASTM" refers to the *American Society for Testing and Materials*, current edition.
8. "RSKSOP" refers to *Robert S. Kerr (Environmental Protection Agency Laboratory) Standard Operating Procedure*.
9. "LUFT" refers to the state of California *Leaking Underground Fuel Tank Field Manual*, 1988 edition.
10. *International Journal of Environmental Analytical Chemistry*, Volume 36, pp. 249-257, "Dissolved Oxygen and Methane in Water by a Gas Chromatography Headspace Equilibration Technique," by D. H. Campbell, J. T. Wilson, and S. A. Vandegrift.

APPENDIX B

ADDITIONAL SITE DATA

TABLE B.1
HYDRAULIC CONDUCTIVITY AND TRANSMISSIVITY RESULTS
SITE OT-24
INTRINSIC REMEDIATION TS
MACDILL AFB, FLORIDA

Well Number	Total Depth (FT) BLS	Hydraulic Conductivity Slug Test (FT/DAY)	Transmissivity Pumping Test (FT/DAY)
OB-1	20.3	17	1,626 (11*)
MD24-1	20.0	NA	NA
MD24-2	20.0	5	737 (5*)
MD24-3	20.0	9	NA
MD24-4	20.0	6	NA
MD24-5	12.0	12	NA
MD24-6	12.5	13	NA
MD24-7	12.2	7	NA
MD24-9	12.2	5	NA
MD24-10	12.3	NA	NA

Source: CH2M Hill, 1991a

(*) Hydraulic conductivity is ft/day assuming saturated aquifer thickness of 20 ft.

NA = No data.

TABLE B.2
FIELD MEASUREMENTS AND SELECTED WATER QUALITY PARAMETERS
TAKEN DURING AQUIFER TEST AUGUST 1989
SITE OT-24
INTRINSIC REMEDIATION TS
MACDILL AFB, FLORIDA

Sampling Event	1	2	3
Date/Time	8-1-89/1700	8-2-89/0900	8-3-89/0855
Time Since Start of Pumping (hours)	8	24	48
<u>Field Measurements</u>			
Temperature (C)	33	33	28
Conductivity ($\mu\text{mhos/cm}$)	1,320	1,250	1,300
pH	7	6.7	6.6
<u>Water Quality Analysis</u>			
BTEX* ($\mu\text{g/l}$)	1,710	1,515	1,210
Naphthalene ($\mu\text{g/l}$)	30	NA	28
TOC ($\mu\text{g/l}$)	18.2	NA	16.9
Lead ($\mu\text{g/l}$)	<0.0002	NA	<0.002
Iron ($\mu\text{g/l}$)	4.67	NA	4.36
Hardness ($\mu\text{g/l}$)	392	NA	390

Source: CH2M Hill, 1991a

* = Total benzene, toluene, ethylbenzene, and xylenes.

NA = Not analyzed.

TABLE B.3
SOIL PCB DATA
PUMPHOUSE 75 (SITE 57)
INTRINSIC REMEDIATION TS
MACDILL AFB, FLORIDA

Parameter	SS01	SS02	SS03	SS04	SS05	SS06
Arochlor 1260 ($\mu\text{g}/\text{kg}$)	2300	870	--	250	180	--

Source: BVWS, In Preparation

-- Sample not collected.